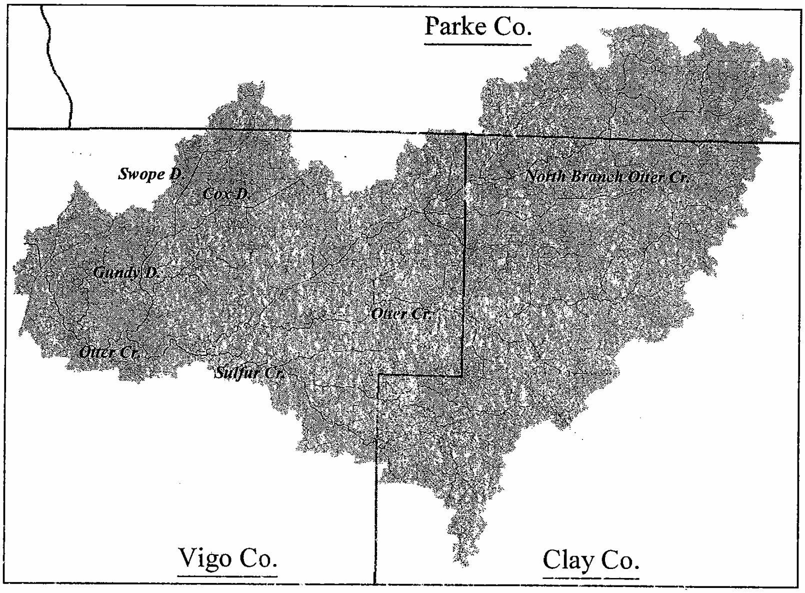
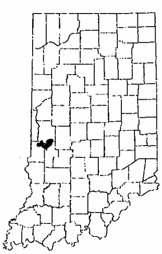
Cox Ditch and Otter Creek Macroinvertebrate Biomonitoring Results (1991-94)

by

Stephen P. Wente

Lake Hart Research





A Report for the

Indiana Department of Natural Resources
Division of Soil Conservation
Lake and River Enhancement Program

and the

Vigo County Soil and Water Conservation District

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Indiana Department of Natural Resources
Division of Soil Conservation
Lake and River Enhancement Program
402 W. Washington St. Room W265
Indianapolis, IN 46204-3882

and the

Vigo County Soil and Water Conservation District
Honey Creek West
3241 S. Third Place
Terre Haute, IN 47802

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EXECUTIVE SUMMARY

The Lake and River Enhancement Program (LARE) of the Indiana Department of Natural Resources (IDNR) is considering funding a land treatment project in Vigo County, IN. The land to be treated is located in the Cox Ditch watershed. Cox Ditch is a small tributary to a high quality stream named Otter Creek. The intent of the LARE project is to improve the water quality and biological integrity of Otter Creek. Lake Hart Research (LHR) was contracted to setup a biological monitoring program to measure the LARE project's performance. Specifically, LHR was contracted to:

1. review existing sources of information that are pertinent to the water quality and biological integrity of the Otter Creek watershed;
2. establish a biological monitoring and habitat assessment pretreatment (baseline) data set from which the success of the proposed LARE project can be evaluated;
3. evaluate the LARE project's potential for success (from the standpoint of biological improvement) and make recommendations for project improvements; and
4. suggest alternative projects.

The first objective, "review existing sources of information...", was accomplished by reveiwing historical fisheries data, IDEM fish tissue and IDEM sediment chemistry data, and noting incidental observations of fish and freshwater mussels during macroinvertebrate sampling (biological monitoring). This background information yeilded information indicating that Otter Creek contains a diverse fish community and several species of mussels. Sediments and fish appear to be free of serious chemical contamination. However, a number of pesticides were detected at low levels in fish tissue samples in both 1984 and 1991. The contamination is far below concentrations that are considered harmful to health.

The second objective, "establish a biological monitoring pretreatment (baseline) data set...", was accomplished using biological monitoring of the aquatic macroinvertebrate community, habitat assessment, and land use analysis. Determination of pretreatment conditions was made dificult by the adverse effects of powerline right-of-way maintenance. Several large sections of riparian vegetation were removed for this maintenance. Fortunately, IDEM sampled macroinvertebrates in 1991 prior to the maintenance. By combining the IDEM and LHR data sets, it was possible to determine pretreatment conditions as well as measure the impact of the powerline maintenance to several river miles of Otter Creek.

The third objective, "evaluate its potential for success (from the standpoint of biological improvement) and make recommendations for project improvements", was accomplished by examining the damage potential of sites within the Otter Creek watershed. This technique indicates sites within the Cox Ditch watershed have little potential to seriously damage the Otter Creek watershed's water quality.

The final objective, "suggest alternative projects", is contained in the report recommendations. Recommendations are organized by level of public commitment. These recommendations range from abandoning the LARE project to minimizing the impacts of powerline maintenance and purchasing development rights in riparian zones.

During the course of this research several water quality problems were identified within the Otter Creek watershed: The identified problems were:

1. riparian vegetation removal associated with powerline right-of-way maintenance;
2. encroachment of non-forested land uses into the riparian zones;
3. channelization for drainage improvement purposes; and
4. low-level pesticide contamination of fishes.

All of the identified problems could be mitigated by maintaining a 50 - 100 m wide riparian zone of woody vegetation.

Otter Creek is quite unique in that it is a stream that appears to have good water quality, contains a high quality fish and mussel fauna, and is in close proximity to people (Terre Haute, IN). These three characteristics would seem to present an excellent opportunity to protect water quality and biodiversity in a setting where people could reap the aesthetic and recreational benefits this high quality stream has to offer.

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Stephen P. Wente

1. INTRODUCTION

The Lake and River Enhancement Program (LARE) of the Indiana Department of Natural Resources (IDNR) is considering funding a project to implement various erosion control practices within the Cox Ditch drainage area of Otter Creek watershed. The LARE project's purpose is to improve the water quality and biological integrity (defined below) of the Otter Creek watershed. The author was contracted to initiate a biological monitoring program to measure changes in water quality in the Otter Creek watershed attributable to the LARE project. This paper reports the results of the monitoring effort to establish pretreatment conditions, reviews historical information related to the water quality of the Otter Creek watershed, performs a candid appraisal of the proposed LARE project's potential for success, and suggests additional or alternative projects.

Biological integrity is defined as "the ability to support and maintain a balanced, integrated, adaptive community with a biological diversity, composition, and functional organization comparable to those of natural aquatic ecosystems in the region" (Frey 1977; Karr and Dudley 1981). Biological integrity should be thought of as a continuous variable (various shades of gray) rather than a discrete variable (black or white, legal or illegal). Different portions of the Otter Creek watershed exhibit various degrees of biological integrity. The desired condition is that all portions of the watershed should exhibit a high degree of biological integrity. This is different from a purely preservationist perspective in which a totally natural condition is sought. An endpoint based upon biological integrity, allows anthropogenic alterations of the environment. However, biological integrity is highest when the impacts of those alterations are minimized. Since the LARE project is designed to minimize the impact of some anthropogenic alterations, its effectiveness should be measurable by its effects on Otter Creek's biological integrity.

The LARE program is designed to provide economic assistance to soil and water conservation districts (SWCDs) for the purposes of enhancing the water quality and biological integrity of lakes as well as flowing water systems (rivers, streams, and creeks). Recently, the LARE program has become concerned with monitoring the effectiveness of the various treatments used in its projects. The LARE program is not a large program in terms of either personnel or financial resources. This monitoring should help to ensure the program's limited resources are spent wisely and efficiently. The information provided by this monitoring project and other's like it will allow resources to be targeted to effective treatments.

For consistency purposes, macroinvertebrates were chosen by LARE personnel as the biological community to be sampled across all LARE monitoring projects. An advantage of macroinvertebrates is that they have short life cycles, and therefore, may respond to treatment effects more quickly than longer lived organisms such as fish.

1.1 Objectives

The goal of this research is to measure the water quality and biological integrity in the vicinity of Cox Ditch and provide insights into the problems afflicting this watershed and potential solutions. In order to obtain this goal, the following objectives were defined:

1. review existing sources of information that are pertinent to the water quality and biological integrity of the Otter Creek watershed;
2. establish a biological monitoring and habitat assessment pretreatment (baseline) data set from which the success of the proposed LARE project can be evaluated;
3. evaluate the LARE project's potential for success (from the standpoint of biological improvement) and make recommendations for project improvements; and
4. suggest alternate projects.

1.2 Site Description

The Otter Creek watershed is located in portions of Vigo, Parke, and Clay Counties in Indiana (figure 1.2-1). Otter Creek flows westward to the Wabash River. It is fed by three major tributaries -- North Branch, Sulfur Creek, and Gundy Ditch. The majority of the Otter Creek watershed is characterized by moderate topographic relief and natural (unchannelized) drainage-ways. The land usage of this watershed is diverse with a relatively high proportion of forested area.

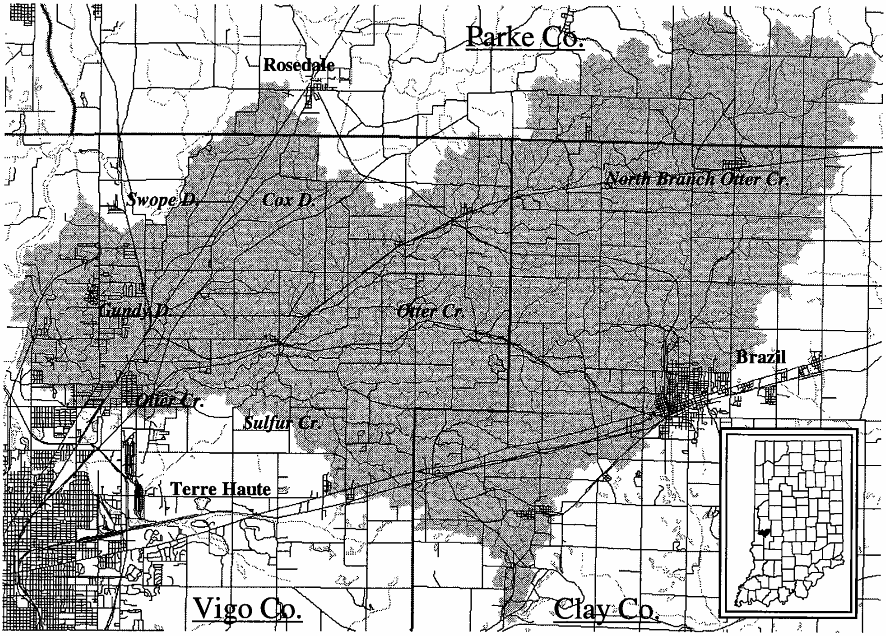

Figure 1.2-1. Map of Otter Creek watershed showing drainage-ways in relation to relevant landmarks. (Interpretation of this admittedly cluttered map may be facilitated by referring to the cover artwork.)

The Cox Ditch of interest to this research is referred to as Cox No 2 Ditch on the USGS's Rosedale quadrangle topographic map (USGS 1962). It is located in north-central/eastern Vigo county and drains southwesterly to join with Swope Ditch to form Gundy Ditch. Gundy Ditch drains farther south to Otter Creek. North and east of these ditches, Cox No 1 Ditch drains northward into Parke County, past the east-side of Rosedale, IN, into Big Raccoon Creek. The area between Big Raccoon and Otter Creeks in the Cox Ditches' vicinity is characterized by little topographic relief and artificial (channelized) drainage-ways. This area is a remnant of the Montclair glacial river valley (Wayne 1956). Its soils are extremely sandy and land usage is predominantly agricultural. For the remainder of this report, Cox No 2 Ditch will simply be referred to as Cox Ditch. Cox No 1 Ditch, which is outside the region of interest, will not be referred to again.

1.3 Philosophical Issues

Monitoring the LARE project poses some philosophical questions:

1. What is the resource of value that the LARE project is attempting to enhance or protect?
2. Where do monitoring responses have to be significant in order to evaluate the effectiveness of the LARE project?

The resource of value could be considered to be Cox Ditch. However, Cox Ditch for much of its stream length is dry for large portions of the year. Certainly, there is little to be gained by enhancing Cox Ditch's water quality and biological integrity. A dry streambed after a land treatment project will not support fish and/or aquatic insects with any more success than it did before the project.

Cox Ditch's aesthetic, recreational, and wildlife benefits and values are negligible as well. It is a channelized ditch with, at most, only a narrow band of vegetation along its banks. For large stretches of the ditch's length, there is no permanent woody vegetation, only a border of grass between the ditch and farm fields.

Similarly, Gundy Ditch, which is formed from the junction of Cox and Swope Ditches, is probably not a good choice as a resource of value. Although Gundy Ditch probably spends less of the year as a dry streambed, it also lacks habitat for aquatic organisms. It has a stream substrate composed primarily of sand. The trees along its banks are young and small. Without rocks or fallen branches and trees, the stream has little habitat for aquatic organisms. Certainly, its macroinvertebrate community would be difficult to sample consistently. If the macroinvertebrates cannot be sampled consistently, it would be impossible to determine the effects of the LARE project.

Otter Creek, which receives the flow of Gundy Ditch, is an excellent aquatic resource. This stream flows year-round, generally has excellent habitat, and supports a rich fauna of fish, freshwater mussel, and aquatic macroinvertebrates. The only problem with using Otter Creek macroinvertebrates to measure the effectiveness of the proposed LARE project is that Otter Creek is so far downstream from the LARE project area. With the project area and the resource of value separated by large distances, it may be difficult to measure a significant treatment response in the Otter Creek macroinvertebrate community. However, the goal of the LARE project is to enhance water quality. If the project is capable of enhancing water quality only in regions of the stream that are typically dry or lack suitable habitat for aquatic organisms, then the project cannot be successful and should be discontinued.

It is important the assessment strategy not be a search for significant results to justify the expenditure of funds on a particular project. Instead the assessment design should realistically evaluate the ability of a project to achieve its goal.

2. BACKGROUND INFORMATION

The first objective is to review existing information that is pertinent to the water quality and biological integrity of the Otter Creek watershed. In order to accomplish this objective historical fisheries data was reviewed, IDEM fish tissue and sediment chemistry data were evaluated, and the author's field notes on incidental observations of fish and freshwater mussels in this watershed are discussed.

Historical fisheries data was reviewed for two reasons. First, this data can provide information relevant to judging fish community's biological integrity, and therefore, water quality. Secondly, some people judge the value of a stream by the fishery it contains. While it is true recreational fishing produces benefits that may indicate a portion of the stream's value to society. This is not the only benefit and therefore, not the sole measure of a stream's value. In reality, streams produce many benefits (including many benefits that are difficult to measure econometrically). However, if a stream does have a diverse and healthy fish community consisting of both game and non-game species, this indicates the stream has some value, and therefore, potentially merits the expenditure of public funds for protection and preservation.

Fish tissue chemistry results are reviewed for two reasons. First chemical contamination of the fish in a waterbody is a good indication that water quality or other environmental problems are present. Organisms, in general, can concentrate organic contaminants to very high levels. The ability of these organisms to concentrate chemicals is unfortunate in many environmental respects. However from an environmental monitoring standpoint, this ability can be used to detect environmental problems at concentrations lower than could be detected in other media (sediment, water, etc.). The second reason has been mentioned previously. The value of a stream for recreation potential is partially dependent on its fishery's value. If the fish are inedible due to chemical contamination, some of the stream's value is diminished. However as mentioned previously, many values are provided by streams. It is unfortunate so many people consider a stream's value to be a direct function of its edible biomass alone.

Sediment chemistry results are reviewed for three reasons. Similar to fish tissue, sediment chemistry analyses may indicate water quality problems. The second reason is financial. Contaminated sediment can be incredibly expensive to clean up. If a watershed contains contaminated sediments that are causing water quality problems, the solution to the problem is likely to be much more expensive than the LARE program can afford. If contaminated sediments are the major water quality problem, public moneys would be unwisely spent remediating lessor problems in a watershed that will continue to experience major water quality problems. The final reason concerns human health. Contaminated sediments can be a health hazard. If contaminated sediments are present, it would not be wise to expose people who will be working on the LARE project or future recreationists to these sediments.

Incidental observations of fish, while not as valuable as data obtained from standardized sampling procedures, can provide some indication of the biological integrity of this important aquatic community. Incidental observations follow a continuum from observations of highly diverse and healthy communities to easily identified fish kills. While standardized sampling procedures and analysis methods will help distinguish slight differences on this continuum, incidental observations will at least, distinguish between profound differences.

Incidental mussel observations can crudely indicate biological integrity the same way incidental fish observations can. However there is one exception to this generality, many aquatic biologists consider the presence of most large native mussel species to be indicators of good water quality conditions. Fish will occur over a wide range of water quality conditions. Mussels, on the other hand, are considered more sensitive and will often be extirpated from poor water quality sites that many species of fish can continue to inhabit. Another reason to be interested in this stream's mussel diversity is that many species of freshwater mussel are swiftly becoming extinct. If endangered mussel species occur here, the expenditure of public funds for watershed protection and enhancement will have greater justification

The following map (figure 2-1) will help identify sample sites in this chapter. Almost all of the background information has been collected from a very small portion of Otter Creek. Some sample sites were described only as "upstream of Anaconda". This refers to an industry that IDEM was monitoring. Today this facility is named "Alcan". These upstream samples probably came from the business 41 vicinity on Otter Creek.

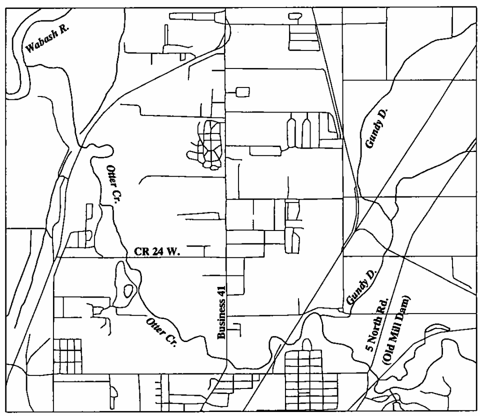

Figure 2-1. Map of Otter Creek between the Old Mill Dam and mouth.

2.1 Methods

2.1.1 Historical Fisheries Data

A literature search was performed and regional fisheries authorities interviewed in order to locate historical fisheries data. Gerking (1945) did not sample the Otter Creek watershed during his statewide fish survey. Dr. Thomas Simon, the current State Ichthyologist, has not sampled in this watershed and was unaware of any fish surveys in this watershed except for a study by Dr. Whitaker (1976) of Indiana State University. Additionally, no IDNR fisheries reports were located. Whitaker's (1976) species list is reported with minor taxonomic modifications to reflect current taxonomic nomenclature.

2.1.2 Fish Tissue Chemistry

IDEM's fish tissue toxic chemistry database was searched for Otter Creek watershed data. Sample sites are listed in table 2.1.2-1. IDEM's sampling methods are detailed in the standard operating procedures manual of the BSS (IDEM 1993). Two samples, one upstream and one downstream of an industry located approximately 1/2 mile upstream of CR 24 West (CR 24 West is site M1 in figure 3.1.1-1), were collected in 1984. The 1984 downstream sample was probably collected in the CR 24 West vicinity. In 1991, three more samples (all at CR 24 West) were collected. One of the 1991 samples (20300985) was subdivided to create a laboratory duplicate sample (20301006). This laboratory duplicate was analyzed for metals only. The 1984 samples were analyzed by the Indiana State Department of Health's (ISDH) Food and Dairy Laboratory. The 1991 samples were analyzed by HLA, a private contract laboratory in Hazleton, WI.

Table 2.1.2-1. IDEM fish tissue chemistry sample sites by location and date.

Location	Date	Sample Identifier	Species	Sample Type
Otter Creek				
Upstream Anaconda	8/24/84	049-84	Golden redhorse *Moxostoma erythurum* (Rafinesque)	Whole fish (o*)
Downstream Anaconda	8/2/84	050-84	Spotted sucker *Minytrema melanops* (Rafinesque)	Whole Fish (o)
CR 24 West	8/27/91	20300984	Black redhorse *Moxostoma duquesni* (Lesuer)	Skin-on fillets, scaleless (o)
CR 24 West	8/27/91	20300985	Spotted bass *Micropterus punctulatus* (Rafinesque)	Whole fish (o)
CR 24 West	8/27/91	20300986	Rockbass *Ambloplytes rupestris* (Rafinesque)	Whole fish (o)
CR 24 West	8/27/91	20301006[a]	Spotted bass *Micropterus punctulatus* (Rafinesque)	Whole fish (ld)

*o = original and ld = laboratory duplicate.
[a] The laboratory duplicate, 20301006, was run for metals only (i.e., no pesticide and PCB results).

2.1.3 Sediment Chemistry

IDEM's sediment toxic chemistry database was searched for Otter Creek watershed data. Sample sites are listed in table 6.1-1. IDEM's sampling methods are detailed in the standard operating procedures manual of the Biological Studies Section (IDEM 1993). Two samples, one upstream and one downstream of an industry located approximately 1/2 mile upstream of CR 24

West (CR 24 West is site M1 in figure 2.1.1-1), were collected in 1984. The 1984 downstream sample was probably collected in the CR 24 West vicinity. In 1992, two more samples (both at CR 24 West) were collected. The 1992 samples are field duplicates of each other.

Table 2.1.3-1. IDEM sediment chemistry sample sites by location.

Location	Date	Sample Identifier	Sample Type
Otter Creek			
Upstream Anaconda	7/24/84	D1827-84	Sediment Composite (o*)
Downstream Anaconda	7/24/84	D1828-84	Sediment Composite (o)
CR 24 West	6/29/92	20700412	Sediment Composite (o)
CR 24 West	6/29/92	20700422	Sediment Composite (fd)

*o = original sample and fd = field duplicate.

Sediment sample analyses are compared to background estimates from Wente (1994). These estimates are derived from the same data set -- IDEM's sediment toxic chemistry database. These background estimates consider widespread low level contamination to be a part of background. In other words, these background estimates do not represent "pristine" conditions.

2.1.4 Incidental Observations of Fish

Several fish were captured incidentally during macroinvertebrate sampling. As the substrate upstream of the kicknet was disturbed during macroinvertebrate sampling, many of the fish that occupied the substrate were captured along with the macroinvertebrates. Fish were identified by Brant Fisher (now an aquatic non-game biologist for IDNR) and the author on site and returned to the stream. Additional incidental observations of fish during macroinvertebrate sampling are also reported.

2.1.5 Incidental Observations of Freshwater Mussels

Evidence that several species of freshwater mussel are currently, or have recently, inhabited the Otter Creek watershed was observed. All observations were incidental (i.e., no formalized sampling procedure was followed). However, these observations are reported since the presence and diversity of this organism group is generally considered to indicate good water quality.

2.2 Results

2.2.1 Historical Fisheries Data

In Whitaker's study, 57 species of fish representing 10 families were collected from a single Otter Creek site (table 2.2.1-1). This site was repeatedly sampled over a twelve year period in order to obtain a final tally of 57. Whitaker's site, below the Old Mill Dam, is the same site as the M3 macroinvertebrate sample site (figure 3.1.1-1). It is located just upstream of the confluence of Gundy Ditch with Otter Creek.

Table 2.2.1-1. Fish collected from the Old Mill Dam site on Otter Creek (Whitaker 1976).

Scientific Name*	Common Name
Petromyzontidae	
Icthyomyzon unicuspis Hubbs and Trautman	Silver lamprey
Cluepidae	
Dorosoma cepedianum (Lesueur)	Gizzard shad
Esocidae	
Esox americanus Gmelin	Grass pickerel
Cyprinidae	
Campostoma anomalum (Rafinesque)	Stoneroller
Cyprinus carpio Linnaeus	Carp
Ericymba buccata (Cope)	Silverjaw minnow
Hybognathus nuchalis Agassiz	Central silvery minnow
Hybopsis storeriana (Kirkland)	Silver chub
Nocomis (Hybopsis) micropogon (Cope)	River chub
Notemigonus chrysoleucas (Mitchill)	Golden shiner
Notropis atherinoides Rafinesque	Emerald shiner
Notropis blennius (Girard)	River shiner
Notropis boops Gilbert	Bigeye shiner
Notropis chrysocephalus (Rafinesque)	Striped shiner
Notropis rubellus (Agassiz)	Roseyface shiner
Notropis spilopterus (Cope)	Spotfin shiner
Notropis stramineus (Cope)	Sand shiner
Notropis umbratilis (Girard)	Redfin shiner
Notropis volucellus (Cope)	Mimic shiner
Phenacobius mirabilis (Girard)	Suckermouth minnow
Phoxinus (Chrosomus) erythrogaster (Rafinesque)	Southern redbelly dace
Pimephales notatus (Rafinesque)	Bluntnose minnow
Semotilus atromaculatus (Mitchill)	Creek chub
Catostomidae	
Carpiodes carpio (Rafinesque)	River carpsucker
Carpiodes cyprinus (Lesueur)	Quillback
Catostomus commersoni (Lacepede)	White sucker
Erimyzon oblongus (Mitchill)	Creek chubsucker
Hypentelium nigracans (Lesueur)	Northern hogsucker
Ictiobus cyprinellus (Valenciennes)	Bigmouth buffalo
Ictiobus niger (Rafinesque)	Black buffalo
Minytrema melanops (Rafinesque)	Spotted sucker
Moxostoma duquesnei (Lesueur)	Black redhorse

Moxostoma erythurum (Rafinesque)	Golden redhorse
Moxostoma valenciennesi Jordan	Greater redhorse
Ictaluridae	
Ictalurus melas (Rafinesque)	Black bullhead
Noturus miurus Jordan	Brindled madtom
Fundulidae	
Fundulus notatus (Rafinesque)	Blackstripe topminnow
Atherinidae	
Labidesthes sicculus (Cope)	Brook silverside
Centrarchidae	
Ambloplytes rupestris (Rafinesque)	Rock bass
Lepomis cyanellus Rafinesque	Green sunfish
Lepomis gulosus (Cuvier)	Warmouth
Lepomis humilis (Girard)	Orangespotted sunfish
Lepomis macrochirus Rafinesque	Bluegill
Lepomis megalotis (Rafinesque)	Longear sunfish
Lepomis microlophus (Günther)	Redear sunfish
Micropterus dolomieui Lacepede	Smallmouth bass
Micropterus punctulatus (Rafinesque)	Spotted bass
Micropterus salmoides (Lacepede)	Largemouth bass
Pomoxis annularis Rafinesque	White crappie
Pomoxis nigromaculata (Lesueur)	Black crappie
Percidae	
Etheostoma blennioides Rafinesque	Greenside darter
Etheostoma caeruleum Storer	Rainbow darter
Etheostoma flabellare Rafinesque	Fantail darter
Etheostoma nigrum Rafinesque	Johnny darter
Etheostoma spectabile (Agassiz)	Orangethroat darter
Percina caprodes (Rafinesque)	Logperch
Percina maculata (Girard)	Blackside darter

* Scientific names follow Lee et al (1980 ~ et seq.). Names in parenthesis within scientific names are the genera names used by Whitaker (1976).

2.2.2 Fish Tissue Chemistry

A complete listing of chemical analysis results appears in appendix C. Abbreviated lists of the most interesting results are presented in tables 2.2.2-1 and 2.2.2-2. The abbreviated list contains results for all samples for each analyte detected in at least one sample. The "% lipids" entry at the bottom of table 2.2.2-2 indicates the lipid content of the samples. Many organic compounds accumulate in tissue samples in proportion to the tissue's lipid content.

Table 2.2.2-1. IDEM heavy metal fish tissue chemistry results from 1984 (shaded) and 1991.

	IDEM Sediment Chemistry Results (ppb)					
Element Name	**049-84**	**050-84**	**20300984**	**20300985**	**20300986**	**20301006**
Arsenic	54.00	52.00	N.A.	N.A.	N.A.	N.A.
Cadmium	< 20.00	30.00	< 10.00	< 10.00	20.00	< 10.00
Chromium	760.00	260.00	N.A.	N.A.	N.A.	N.A.
Copper	350.00	410.00	N.A.	N.A.	N.A.	N.A.
Lead	< 90.00	< 90.00	10.00	60.00	60.00	29.00
Mercury	79.00	120.00	130.00	160.00	70.00	130.00
Zinc	16,700.00	19,800.00	N.A.	N.A.	N.A.	N.A.

N.A. = Not analyzed.

Numbers preceded by "<" indicate that the actual value is below the instrument detection limits. The number following the "<" is the detection limit.

Table 2.2.2-2. An abbreviated list of IDEM pesticide and PCB fish tissue chemistry results from 1984 (shaded) and 1991.

	IDEM Fish Tissue Chemistry Results (ppb)				
Chemical Name	**049-84**	**050-84**	**20300984**	**20300985**	**20300986**
Alpha BHC	1.000	< 1.000	< 8.000	< 8.000	< 8.000
Heptachlor Epoxide	21.000	10.000	< 8.000	< 8.000	< 8.000
Dieldrin	18.000	8.000	< 10.000	15.000	< 10.000
4,4'-DDE	60.000	12.000	< 10.000	52.000	< 10.000
4,4'-DDD	10.000	2.000	< 10.000	< 10.000	< 10.000
4,4'-DDT	40.000	7.000	< 20.000	< 20.000	< 20.000
Gamma (trans) Chlordane	10.000	4.000	< 8.000	< 8.000	< 8.000
Alpha (cis) Chlordane	23.000	9.000	< 8.000	< 8.000	< 8.000
Hexachlorobenzene	1.000	1.000	< 10.000	< 10.000	< 10.000
1,4'-DDE	N.A.	N.A.	< 20.000	13.000	< 20.000
Pentachloroanisole	1.000	< 1.000	< 16.000	< 16.000	< 16.000
Oxychlordane	11.000	6.000	< 8.000	10.000	< 8.000
trans-Nonachlor	53.000	17.000	< 16.000	53.000	9.100
cis-Nonachlor	10.000	4.000	< 8.000	18.000	< 8.000
Total PCBs	200.000	248.000	132.000	229.000	70.000
% Lipids	5.82	2.90	2.07	3.99	3.07

Numbers preceded by "<" indicate that the actual value is below the instrument detection limits. The number following the "<" is the detection limit.

N.A. = Not analyzed.

2.2.3 Sediment Chemistry

A complete list comparing chemical analysis results with background concentrations appears in appendix D. An abbreviated list of the most interesting results is presented in table

2.2.3-1. Only one organic contaminant was detected in sediment -- Arochlor 1254. It appears at the bottom of table 2.2.3-1.

Table 2.2.3-1. An abbreviated list of IDEM heavy metal and PCB sediment chemistry results from 1984 (shaded) and 1992 with estimated background concentrations.

Element Name	Estimated Background (ppb)[a]	IDEM Sediment Chemistry Results (ppb) D1827-84	D1828-84	20700412	20700422
Aluminum (Al)	21,100,000	N.A.	N.A.	5,370,000	6,190,000
Antimony (Sb)	3,229.33	200	200	< 5,600	< 5,200
Arsenic (As)	17,600	3,400	4,600	4,500	4,500
Barium (Ba)	190,000	N.A.	N.A.	51,100	51,400
Beryllium (Be)	1,041.27	< 1,600	< 2,900	410	380
Calcium (Ca)	116,000,000	N.A.	N.A.	8,790,000	9,350,000
Chromium (Cr)	71,000	< 3,300	17,000	7,700	8,700
Cobalt (Co)	24,017.95	N.A.	N.A.	7,500	7,300
Copper (Cu)	77,000	4,300	16,000	8,200	8,700
Iron (Fe)	37,000,000	N.A.	N.A.	13,600,000	13,800,000
Lead (Pb)	114,000	12,000	19,000	9,100	10,000
Magnesium (Mg)	20,000,000	N.A.	N.A.	2,130,000	2,360,000
Manganese (Mn)	1,440,000	N.A.	N.A.	895,000	918,000
Mercury (Hg)	237	20	110	30	30
Nickel (Ni)	63,000	12,000	15,000	15,400	14,900
Potassium (K)	2,300,000	N.A.	N.A.	570,000	710,000
Selenium (Se)	1,637.89	100	270	N.A.	N.A.
Sodium (Na)	470,556.35	N.A.	N.A.	117,000	129,000
Vanadium (V)	46,000	N.A.	N.A.	14,300	16,000
Zinc (Zn)	310,000	55,000	76,000	53,900	54,300
Chemical Name					
Arochlor 1254	129.0418	18.000	45.000	< 86.000	< 87.000

[a] Background estimates taken from Wente (1994) appendix table A1 (metals) and A2 (PCB) for non-spatially variable background estimates. Spatially variable background estimates were taken from table C1 and 2 using Vigo County estimates.

N.A. = Not analyzed.

Numbers preceded by "<" indicate that the actual value is below the instrument detection limits. The number following the "<" is the detection limit.

2.2.4 Incidental Observations of Fish

Fish appeared to be abundant at all macroinvertebrate sites sampled. Although no intentional fish sampling was performed for this research, several fish species were observed during macroinvertebrate sampling. At the first macroinvertebrate sampling site (M1, figure 2.2.1-1), one stonecat (*Noturus flavus* Rafinesque) and two fantail darter (*Etheostoma flabellare* Rafinesque) were collected in the kicknet while sampling macroinvertebrates. Additionally, several sucker and sunfish were observed from on top of the bridge at the CR 24 West site. At site M2, two northern hogsucker (*Hypentelium nigracans* (Lesueur)), one greenside darter (*Etheostoma blennioides* Rafinesque), and one fantail darter were collected in the kicknet. At site M3, one greenside darter, one rainbow darter (*Etheostoma caeruleum* Storer), and one fantail darter were collected in the kicknet. Additionally, several blackstripe topminnow (*Fundulus notatus* (Rafinesque)) were observed in the slower water below the Old Mill Dam.

2.2.5 Incidental Observations of Fish

Several fresh (recently) dead and weathered (older) shells were found at macroinvertebrate sample sites M2 and M3. Although no shells were identified (except *Corbicula fluminea* (Müller) in the macroinvertebrate samples), it was apparent from the diversity of shell shapes that several species of mussel inhabit this watershed. Additionally it should be noted that even though *Corbicula* and Sphaeriidae were not present in all macroinvertebrate subsamples listed in table 3.2-1, these mussels were present in profuse numbers at all three sites sampled (M1, M2, and M3) in 1994.

2.3 Discussion

2.3.1 Historical Fisheries Data

Comparison of species richness between streams is problematic when sampling techniques and intensities vary between studies. Whitaker (1976) used seining alone in his study and sampled at several different times of the year. Most of the fish sampling data the author is familiar with involves electro-fishing (or a combination of electro-fishing and seining) and sampling at times of the year when fish communities are more stable (early summer to mid-fall). Possibly, some species that may not continuously inhabit Otter Creek were collected during the species' spawning run.

However, 57 species certainly qualifies the Old Mill Dam as one of the more diverse sites in the state for a stream of this size. For comparative purposes, the largest number of species Dr. Simon has collected in Indiana during a single sampling event using electro-fishing was 56 species at a Tippecanoe River site (personal communication). Brant Fisher and the author collected 50 species from a single sampling event using a combination of electro-fishing and seining at the Tippecanoe and Wabash River confluence (unpublished data). Although neither of these sampling events represent repeated samplings over time, they do give some indication the Otter Creek site is likely to be one of the state's more diverse sites. As previously stated, if a stream does have a diverse and healthy fish community consisting of both game and non-game species, this indicates the stream has some value.

Whitaker's paper is interesting not only for the diversity of fish captured, but also the instability of the fish population at this site. Even though measures were taken to ensure that equal catch effort was invested in each sampling, the number of fish captured per sampling event varied from 52 to 5,344. Species composition of the catches seemed to be equally variable.

It is interesting to speculate that the powerline right-of-way maintenance that impacted the macroinvertebrate community between 1991 and 1994 may explain some of the variability in Whitaker's (1976) data. Possibly the cyclical disturbance of powerline right-of-way maintenance (a large-scale disturbance repeated every few years) accentuated community variability and contributed to the site's measured species richness. By altering water quality and habitat conditions, the maintenance projects may have caused the fish community present at the site to change in species composition from pioneer species immediately after right-of-way maintenance to the more climax community as time since the last maintenance project passed. As the communities changed and species came and went over the time of the sampling (12 years), the species richness measures may have possibly become inflated.

2.3.2 Fish Tissue Chemistry

The heavy metal analysis indicates nothing unusual. The highest metals concentrations are for elements that are essential to the fish's health -- chromium, copper, and zinc (NRC 1993). Mercury can be a major problem in fishes. However, the values in these Otter Creek fishes are far below the levels that most states issue fish consumption advisories (usually between 500 and 1000 ppb).

The pesticide and PCB concentrations are not considered harmful to health. However, the number of detections is somewhat disconcerting. High numbers of detections occur in both of the 1984 samples and in sample 20300985 of the 1991 samples. High numbers of detections occur both up and downstream of the industry that IDEM was monitoring. This indicates the source of these contaminants probably occurs further upstream. The many acres of farm fields in the upper watershed are likely sources.

The PCB concentrations on the other hand, seem to indicate a source between the up and downstream sites. Figure 2.3.2-1 depicts total PCB concentrations for all samples expressed on a percent lipid basis (total PCB / % lipid). The 1984 up and downstream samples differ by more than a factor of two. The 1994 samples from the downstream site seem to indicate the concentrations are declining with time.

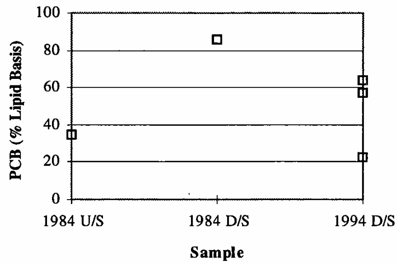

Figure 2.3.2-1. Total PCB concentrations of all samples expressed on a percent lipid basis (total PCB in ppb / % lipid).

Finally, it should be pointed out that fish tissue chemistry data always seem "disconcerting". It bothers people to see contaminant concentrations at anything other than zero. However, it is impossible to measure a zero concentration. Analytical chemistry has progressed to the point where traces of toxic chemicals can be detected in almost anything. As improvements in analytical chemistry techniques continue to detect ever smaller concentrations, it becomes clear the terms "uncontaminated" or "contaminant free" should be replaced with the concept of "acceptably (un)contaminated".

2.3.3 Sediment Chemistry

All of the measured sediment concentrations are below background estimates. Since background estimates are based on 95th percentile estimates from IDEM's data set, five percent of the analyses should result in exceedance of background estimates by random chance alone. Since there are 58 analyses reported in table 2.2.3-1 (only counting analyses in which the detection limit was below the background estimate) three analysis results (approximately five percent of 58) should have exceeded background estimates by random chance alone.

There are two reasons why exceedances did not occur and are not likely in Otter Creek. First, the data set from which background estimates were made contains data from many contaminated sites. Inclusion of contaminated data in the reference data set results in inflated background estimates and therefore, a decreased likelihood the background estimates will be exceeded. In order to minimize inflation of background estimates, the state needs to cull out contaminated data from the reference data sets and re-estimate background concentrations as recommended in Wente (1994). The second reason involves the Otter Creek substrate characteristics in the sample site vicinity. As stated previously, the substrate is almost exclusively sand. Sand is unlikely to retain organic contaminants and dilutes metals analysis results with its inorganic (silicon dioxide) composition. For samples from Otter Creek, non-exceedance of statewide background estimates only indicates that the samples are not grossly contaminated.

Because of Otter Creek substrate characteristics, a more stringent test than comparing these samples to statewide background estimates would be to compare the sites of interest to local background estimates. This is the approach that IDEM followed when it collected an upstream sample to indicate local background concentrations. IDEM was interested in determining if the three downstream samples (one in 1984 and two in 1992) had elevated contaminant levels relative to the upstream or background levels. The problem with this method is there is no real estimate of background variability since only one upstream sample was collected. Without an estimate of background variability, it is impossible to determine the acceptable range of background concentrations. Despite this problem, it is interesting to make the upstream/downstream comparison.

Comparing IDEM's upstream sample (D1827-84) with the three downstream samples, it appears that concentrations are elevated for arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc, and arochlor 1254 especially in 1984. However, all of these contaminants may concentrate in organic materials to some extent. If the organic content of the samples varied, the apparent contamination might be readily explained in this way. Unfortunately, an accurate method for measuring organic carbon content was not available at the time of the 1984 samples. If it is assumed that there is no variation in organic content of any of the samples, the 1992 samples seem to indicate that concentrations of some of the metals are decreasing (or washing downstream) relative to the 1984 samples.

In summary, sediment contamination does not seem to be a large problem in Otter Creek. The sediment concentrations do not exceed the relevant statewide background estimates. If there was some elevation of contaminant levels in the downstream sediment samples relative to local background levels, it is probably declining.

Additionally it should be noted, IDEM considers the 20 miles of Otter Creek evaluated by this agency to be fully supporting of its "aquatic life" designated use. Although, IDEM considers the upper nine miles of this 20 to be threatened by acid mine drainage (IDEM 1990).

2.3.4 Incidental Observations of Fish

In the author's experience, it is not uncommon to catch fish while sampling macroinvertebrates with a kicknet. However, the number of fish per sample, the consistency with which fish were caught, and the diversity of fish caught do seem to indicate the Otter Creek fishery is still in good condition. In fact, fish became somewhat of a nuisance during sampling since fish can eject part of the macroinvertebrate sample from the kicknet as they try to escape. These incidental observations do corroborate Whitaker's (1976) data and indicate the fish communities have not drastically changed (e.g., disappeared).

Additionally, the stonecat (*Noturus flavus* Rafinesque) collected at site M1 does not appear in Whitaker's (1976) species list for site M3. This addition would bring the total fish species richness in the Otter Creek watershed to 58.

2.3.5 Incidental Observations of Freshwater Mussels

The presence of sphaeriidae and corbicula does not necessarily indicate good water quality. Sphaeriidae (the fingernail clam family) are so ubiquitous and so difficult to identify to species that many malacologists (biologists that study mussels) simply omit them from their species lists. Corbicula, on the other hand, are exotic organisms and therefore, their presence by definition is a biological integrity problem.

However, many shells observed at Otter Creek were large native mussel species. Based on obvious morphological differences, the author estimates at least four species of large native mussels were present. Although it is difficult for the author to estimate the value of the Otter Creek watershed to freshwater mussel diversity, the presence of mussels is one more indication that Otter Creek is a natural resource that merits the attention of IDNR's LARE program.

Considering all of background information reviewed -- the fish and mussel diversity data and fish and sediment data. It would appear that Otter Creek is a valuable natural resource that has managed to escape serious environmental degradation. Coupling that assessment with fact that it is close to people would indicate that this resource makes Otter Creek even more valuable. Otter Creek is a resource that people in this area could enjoy without having to drive for hours. However, refering to Otter Creek as a "valuable natural resource" brings up an interesting point.

The stream is valuable in the sense of its biological diversity and water quality. However, it is unlikely that those people who are best able to enjoy and care for this resource, the people who live in or near the watershed, are aware of its value. Since these people do not appreciate Otter Creek's value and probably cannot realize any value from Otter Creek's presence, they do not take care of this resource the way they would a resource with recognized value.

Something as simple as an informational brochure might increase Otter Creek's value to the people who live in or near the watershed. If the brochure was appealing enough, it might even be a selling point for homes in the area. Image how much more people would care for this resource if Otter Creek was considered an asset that increases the value of nearby homes by a few thousand dollars. The point is IDNR might have an easier time enhancing rivers if local landowners appreciate the value of a resource. Especially if they can capture some economic value from the protection and enhancement of that resource.

3. BIOLOGICAL MONITORING

The goal of this biological monitoring project is to measure the difference between the water quality conditions in the Otter Creek watershed before and after the LARE project. The biological monitoring conducted in 1994 measured pretreatment conditions at various points in the watershed. Sample sites were chosen that will isolate and measure the treatment effect.

Two of the selected sample sites were the same sites that IDEM had biologically sampled in 1991. Ideally, since both 1991 and 1994 samples represent pretreatment conditions (conditions prior to the initiation of the LARE project), the results should be combined to provide more accurate estimates of pretreatment conditions and even more importantly, more accurate estimates of variability in the pretreatment conditions. If the LARE project is a success, the post-treatment water quality conditions should be better. Failure of the LARE project would be indicated by post-treatment conditions that were the same or worse. The objective of sections two and three is to establish a biological monitoring and habitat assessment pretreatment data set from which the success of the proposed LARE project can be evaluated.

3.1 Methods

Three sites were sampled on Otter Creek in 1994. The sites were chosen to bracket the confluence of Gundy Ditch with Otter Creek (one upstream and two downstream). Gundy Ditch is the ditch that carries water from Cox Ditch to Otter Creek. The two downstream locations had been previously sampled by IDEM as part of its efforts to develop water quality biological criteria. IDEM macroinvertebrate sampling and habitat assessment methods, subsampling procedures, and data summary metrics (IDEM 1993) were adopted in order to facilitate comparisons with IDEM results from these sites as well as, allow comparisons to the other IDEM sample sites across the state.

To minimize seasonality effects, samples should be collected at approximately the same time of the year. The 1991 IDEM samples were collected on October 18th, 1991. In order to prevent potential inter-comparability problems between samples collected for this project and IDEM samples, macroinvertebrate communities were sampled at all three sites on the same day of the year, October 18th (1994), as the IDEM samples.

A major difference between IDEM procedures and those followed for this research is that no coarse particulate organic matter (CPOM) samples were taken. Since IDEM has not processed, and probably will not process in the foreseeable future, the CPOM samples it has collected, this portion of the IDEM sample protocol was omitted.

Macroinvertebrate samples were preserved in formalin and isopropyl alcohol and transported to the Lake Hart Research laboratory facilities for processing. One hundred organism subsamples were taken following IDEM protocols. Taxonomic identifications were to the family level following IDEM practices and McCafferty (1981). Three biotic metrics were calculated for each sample -- Hilsenhoff Biotic Index (HBI), Ephemeroptera, Plecoptera, and Trichoptera count (EPT), and EPT to chironomid ratio (EPT/Chir).

EPT count is the total number of individuals of the orders ephemeroptera, plecoptera, and trichoptera found in a sample. IDEM's subsamples represent $1/77^{th}$ (one square) of the entire sample per square subsampled. Since, LHR's subsamples represent $1/48^{th}$ of the entire sample per square subsampled, a correction factor of 0.623 (48/77) is applied. Additionally, EPT counts are corrected for subsample size by dividing by the number of squares subsampled. These correction factors convert LHR EPT values into values that are directly comparable to IDEM's data set. All EPT counts are reported as $1/77^{th}$ of the entire sample. The resulting EPT count is rounded to the first decimal place.

EPT/Chir ratio is the EPT count divided by the number of individuals of the family chironomidae found in a subsample. Since these values are ratios of two values from the same subsample, no correction factors are needed. The ratio is already standardized to its subsample, and therefore, subsample size does not present a problem for comparisons between data sets. Similarly, HBI values are inter-comparable since they are also a ratio between two measurements on the same subsample.

Field duplicates were collected at both downstream sample sites. Field duplicates are duplicate samples that are collected in the field according to the same procedures used to collect the original samples. These samples are used to determine the precision with which the biological metrics can be measured at a given site. Large differences in biotic metrics between field duplicates and original samples indicate the imprecision of the measurement technique.

Both field duplicates were resampled during subsampling to create laboratory duplicates. Laboratory duplicates indicate the precision of the subsampling techniques. Large differences in biotic metrics between laboratory duplicates and field duplicates indicate the imprecision of the subsampling technique.

3.1.1 Macroinvertebrate Sample Sites

Table 3.1.1-1 lists relevant macroinvertebrate sample information. Figure 3.1.1-1 depicts the location of the macroinvertebrate sample sites.

Table 3.1.1-1. Macroinvertebrate sample sites by location and date.

Location	Date	Sampled By	Sample Identifier	Referenced in this Paper as: Sample	Site	Sample Type
Otter Creek						
CR 24 West	10/18/91	IDEM	911018205.0	DEM 1 (o)	M1	Original sample
CR 24 West	10/18/91	IDEM	911018205.5	DEM 1 (ld)	M1	Lab duplicate
CR 24 West	10/18/94	LHR	AAA (o)	LHR 1 (o)	M1	Original sample
CR 24 West	10/18/94	LHR	AAB (fd)	LHR 1 (fd)	M1	Field duplicate
CR 24 West	10/18/94	LHR	AAF (ld)	LHR 1 (ld)	M1	Lab duplicate
Business 41	10/18/91	IDEM	911018203.0	DEM 2 (o)	M2	Original sample
Business 41	10/18/94	LHR	AAC (o)	LHR 2 (o)	M2	Original sample
Business 41	10/18/94	LHR	AAD (fd)	LHR 2 (fd)	M2	Field duplicate
Business 41	10/18/94	LHR	AAG (ld)	LHR 2 (ld)	M2	Lab duplicate
Old Mill Dam	10/18/94	LHR	AAF (o)	LHR 3 (o)	M3	Original sample
North Branch Otter Creek						
Private Bridge NE 1/4 Sec. 23	10/18/91	IDEM	911018201.0	DEM 4 (o)	M4	Original sample

*IDEM = DEM = Indiana Dept. of Environmental Management, LHR = Lake Hart Research, o = original sample, fd = field duplicate, and ld = laboratory duplicate.

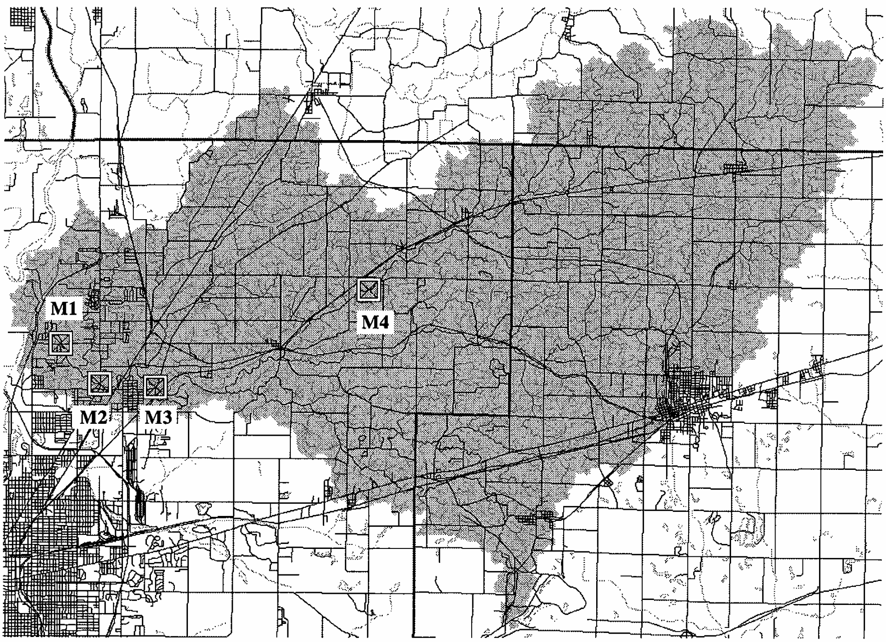

Figure 3.1.1-1. Map of macroinvertebrate sample sites.

The drainage area above each of the macroinvertebrate sample sites varies in size. Site M1 (the furthest downstream) drains 77,878 acres. Site M2 drains 74,204 acres. Site M3 drains 61,932 acres. Lastly, site M4 drains 23,212 acres.

The two sites resampled in 1994 had to be moved by small distances. Site M1, in 1994, was sampled approximately 100 meters upstream of the site sampled 1991. This is the next riffle upstream from the 1991 sample site. It was deemed necessary to move this due to changes in instream habitat. Similarly, site M2 was moved approximately 20 meters upstream (under the Business 41 bridge) due to similar changes.

3.2 Results

Results of the macroinvetebrate subsample identifications are presented in table 3.2-1. The data is summarized at the bottom of table 3.2-1 using the three biotic metrics -- EPT, EPT/Chir, and HBI. Photocopies of the 1994 macroinvertebrate bench sheets (signed laboratory worksheets) are included in Appendix A. IDEM's bench sheets are on file with the IDEM, OWM, BSS.

Table 3.2-1. Macroinvertebrate identification results from 1991 (shaded) and 1994.

Taxon (HBI Tolerance Value)	Macroinvertebrate Samples*										
	LHR 1 (o)	LHR 1 (fd)	LHR 1 (ld)	DEM 1 (o)	DEM 1 (ld)	LHR 2 (o)	LHR 2 (fd)	LHR 2 (ld)	DEM 2 (o)	LHR 3 (o)	DEM 4 (o)
Arthropoda											
Insecta											
Ephermeroptera											
Tricorythidae (4)	1	1	5	1	4	7	3	1	27	19	
Caenidae (7)			2			1			1		3
Oligonuridae (2)				6	4	3			1		6
Heptageniidae (4)	1	6		2	1	3			1	1	4
Odonata											
Calopterygidae (5)										1	
Plecoptera											
Perlidae (1)											22
Taeniopterygidae (2)	6	7	3	10	11	7	7	6	10	8	
Chloroperlidae (1)								1		1	
Trichoptera											
Philopotamidae (3)					1	2	2	4	7	12	14
Polycentropodidae (6)								1			
Hydroptilidae (4)	1	5	5	68	64	16	16	4	19	32	5
Limnephilidae (4)										9	
Hydropsychidae (4)	1			10	23	25	12	8	13	16	15
Coleoptera											
Elmidae (4)	8	13	15	3		7	7	1	5	4	5
Limnichidae (0)										1	
Diptera											
Tipulidae (3)			1								
Chironomidae (6)	19	20	22	24	66	76	35	41	51	57	19
Empididae (6)	31	42	28	4	4	14	9	8	4	23	7
Ceratopogonidae (6)										1	
Simuliidae (6)				4	7			1	1	17	
Other Arthropoda											
Acari (4)	20	16	24	8	5	19	10	8	13	4	
Asellidae (8)	2		2								
Astacidae (6)		1									
Mollusca											
Gastropoda											
Lymnaea (6)	9	3	3								
Physa (8)											2
Pelecypoda											
Sphaeriidae (8)	1		1	1	1	1				2	
Corbicula (0)		2								2	
Platyhelminthes											
Turbellaria (4)			1								
Annelida											
Olgochaeta (0)	350	137	187	68	32	31	8	3	3	22	4
Nematomorpha (0)						5	1				
EPT[a]:	6.2	11.8	9.4	97	108	39.9	24.9	15.6	39.5	61.1	34.5
EPT/Chir:	0.526	0.950	0.682	4.040	1.636	0.842	1.143	0.610	1.550	1.719	3.630
HBI:	5.18	5.04	5.04	4.26	4.66	4.91	4.71	4.99	4.56	4.84	3.77

*LHR = Lake Hart Research, DEM = Indiana Dept. of Environmental Management, o = original sample, fd = field duplicate, and ld = laboratory duplicate.

[a]EPT counts are reported as 1/77th of the entire sample.

3.3 Discussion

Three biotic metrics of macroinvertebrate community health were calculated for each of the samples. Each will be discussed separately in the next three subsections.

3.3.1 EPT Count

EPT count is a measure of the abundance of individual organisms of the families ephemeroptera, plecoptera, and trichoptera. EPT counts in table 3.2-1 are mathematically transformed (standardized) to make them reflective of the abundance in the original sample and comparable across samples. Higher EPT counts generally indicate better conditions in terms of water and/or habitat quality. An exception occurs when excessive nutrients enter waterways. The additional nutrients cause abundance of all species to increase resulting in high EPT counts. Since excessive nutrients are a major problem in agricultural areas, EPT counts should be interpreted in conjunction with other biotic metrics.

Figure 3.3.1-1 compares the EPT counts from both 1991 and 1994. The 1994 counts from site M1 are much lower. In 1991, there was a large difference between sites M1 and M2 with M1 having much higher counts. In 1994, site M1 has lower counts than any other site on the stream. Site M2 EPT counts were much more stable over time. Interestingly, EPT counts decrease from downstream to upstream (M1 - M4) in 1991 and follow the opposite trend in 1994.

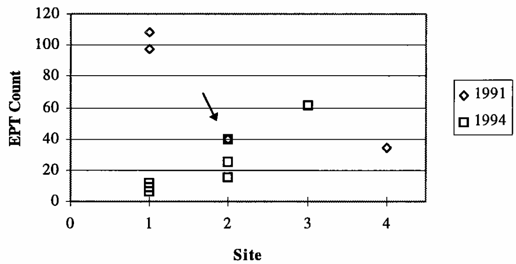

Figure 3.3.1-1. EPT results from 1991 and 1994 (arrow indicates the same value for 1991 and 1994). Higher is typically better.

There are several reasons why IDEM's procedures were adopted for the sampling methods. One reason that has already been alluded to, is it makes it possible to extend the time period over which the pretreatment conditions were measured. This makes it possible to estimate year-to-year variability at sites that IDEM happened to have previously sampled (sites M1 and M2). Another reason is that makes it possible to compare the sampled watershed to other watersheds in IDEM's reference data set.

In figure 3.3.1-2, the EPT scores have been converted to percentile ranks according to other EPT scores from IDEM reference site data set. This data set contains scores from sites around the state that IDEM personnel considered to be reflective of the best habitat and water quality in an area. Looking at the Otter Creek sites in this manner makes it possible to compare these sites to other sites across the state.

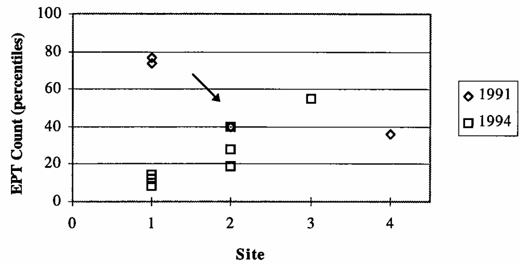

Figure 3.3.1-2. EPT results from 1991 and 1994 expressed as percentiles (arrow indicates the same value for 1991 and 1994). Higher is typically better.

Changes are dramatic at site M1. In figure 3.3.1-2, it can be seen that the EPT count at site M1 changed from the 75th percentile to below the 10th percentile. In other words, the 1991 samples from site M1 were better than 75% of the reference sites in IDEM's data set. In 1994, the same site was only better than 10% of the sites. At site M2, the score was much more stable. Although, the 1991 score is at the high end of the 1994 scores from site M2.

The utility of any biotic metric is dependent on its ability to respond predictably and consistently across a range of water quality. The idea behind biotic metrics is to identify some set of organisms that will be present in every sample and has a predictable response to changes in water quality. EPT counts rely on order level taxonomic identifications. Since many of the species within any large taxonomic group may have dissimilar responses to pollution stress, biotic metric's based on larger (higher) taxonomic will have less predictable responses and less certain interpretations. The EPT count is a useful metric, but the inclusion of the additional information from other metrics allows a consensus of information to produce a more reliable interpretation.

3.3.2 EPT to Chironomid Ratio (EPT/Chir)

The EPT to chironomid ratio (EPT/Chir) is a relative measure of the abundance of ephemeroptera, plecoptera, and trichoptera individuals to chironomid individuals. Since EPT/Chir values are relative measures, no mathematical transformations are necessary to make them comparable across samples. Higher EPT/Chir ratios indicate better conditions in terms of water and/or habitat quality. Unlike EPT counts excessive nutrients do not interfere with the interpretation of this metric. The additional nutrients would cause both EPT and chironomid populations to increase. Since the EPT/Chir metric is a ratio, semi-equivalent increases in both the numerator and denominator do not appreciably change the ratio. The major problem with

EPT/Chir ratios is their volatility. Small changes in the denominator (chironomid count) will result in large changes in the EPT/Chir ratio.

Figure 3.3.2-1 compares the EPT/Chir ratios from both 1991 and 1994. The 1991 EPT/Chir ratios from site M1 exhibit the previously mentioned volatility problem. The number of EPT organisms is roughly equal (97 and 108). However, the number of chironomids varies from 24 to 66. It does appear that the EPT/Chir ratios indicate a small change at site M2 and a larger change at site M1. Additionally, site M4 has a high EPT/Chir ratio. Recall that its EPT count that was the lowest of the 1991 counts. Additionally considering all sites together, the EPT/Chir ratios from 1991 and 1994 overlap less than the EPT counts. Only site M3 (1994) has a higher EPT/Chir ratio than the lowest 1991 values.

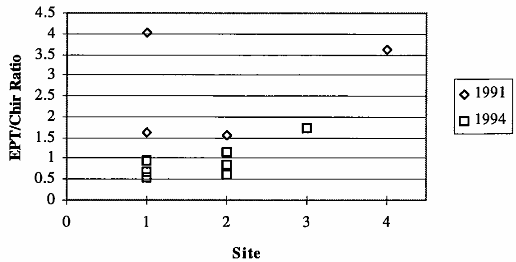

Figure 3.3.2-1. EPT/Chir results from 1991 and 1994. Higher is better.

The EPT/Chir ratios expressed as percentiles figure (3.3.2-2) show the Otter Creek sites are similar to other reference sites in IDEM's data set. Most of the 1991 samples fall between the 40th and 80th percentiles. The 1994 samples occupy a lower range between the 15th and 50th percentiles.

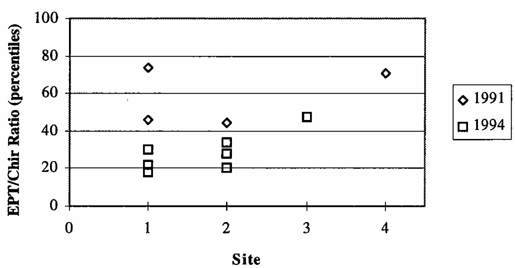

Figure 3.3.2-2. EPT/Chir results from 1991 and 1994 expressed as percentiles. Higher is better.

The EPT/Chir metric has some advantages over the EPT count. One of these advantages is that it has some superior taxonomic resolution since chironomids are identified to the family level. Family level taxonomy is more specific than order level taxonomy. It is the author's opinion that more weight should be given to EPT/Chir ratios during interpretation than EPT counts.

3.3.3 Hilsenhoff Biotic Index (HBI)

The Hilsenhoff biotic index (HBI) is a weighted average of all of the individuals in a sample. Since HBI values are another relative measurement, no mathematical transformations are necessary to make them comparable across samples. Unlike the previous metrics, lower (not higher) HBI values indicate better conditions in terms of water and/or habitat quality. Similar to EPT/Chir ratios, excessive nutrients should not interfere with the interpretation of this metric. The additional nutrients would cause the relative numbers of all families to increase. Since the HBI metric is a ratio of the total number of organisms multiplied by their respective weights to the total number of individuals, semi-equivalent increases in both the numerator and denominator do not appreciably change the ratio. The major problems with the Hilsenhoff biotic index is that the weights were determined by professional judgment (which is subjective by nature) and it was calibrated using data from Wisconsin.

Figure 3.3.3-1 compares the HBI values from both 1991 and 1994. Again, the 1994 HBI values from sites M1 and M2 show degradation from the 1991 values. Two of the 1994 samples from site M1 received the same score of 5.04. Consequently, only two of the three markers appear in figures 3.3.3-1 and 2. Similar to the EPT/Chir results, site M4 is considered to have extremely good water and/or habitat quality. There is no overlap between 1991 and 1994 HBI scores. The lowest 1994 score is slightly higher than the highest 1991 score.

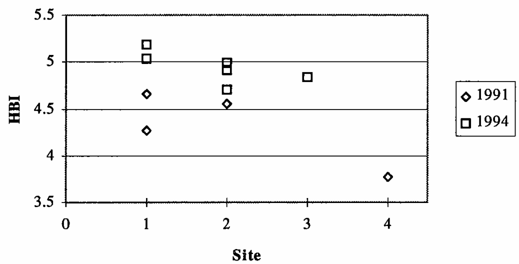

Figure 3.3.3-1. HBI results from 1991 and 1994. Lower is better.

In 1991, the HBI percentiles (figure 3.3.3-2) were very good. Site M4 was the best (lowest) in the entire IDEM reference data set. Even under the worsened conditions in 1994, no sample fell into worst quartile (75-100).

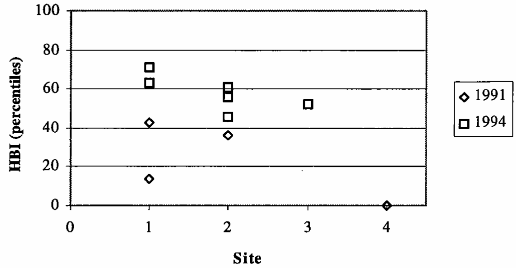

Figure 3.3.3-2. HBI results from 1991 and 1994 expressed as percentiles. Lower is better.

The HBI has advantages over both EPT counts and EPT/Chir ratios. It is almost entirely based on family level taxonomy, and therefore, should have superior resolution. Additionally, the HBI has some additional sensitivity added by a set of weighting factors referred to as HBI tolerance values. These tolerance values are whole numbers between 0 and 10 that are assigned to individual families to indicate the family's sensitivity to pollution. It is the authors professional opinion that this metric should be given the most weight of the three metrics when interpreting results.

3.3.4 Pretreatment Conditions: Part I

The biological monitoring from this research is intended for use in determining pretreatment conditions. The progress of the LARE project will be measured against the pretreatment conditions. If the project is a success, it is expected that the biotic metrics calculated from the future post-treatment sampling will show significant improvement relative to the pretreatment conditions. Failure would be indicated by the same or worse biotic metric scores.

Unfortunately there is a problem even with this simple project evaluation strategy. The pretreatment conditions have changed between samplings. One of many reasons for using the IDEM data was to check between year variability by comparing the 1991 and 1994 data. Between year variability should have been small in a stream this large (assuming between year variability would be mainly due to changes in water flows). However, all of the metrics show changes at sites M1 and M2. Many of these changes are quite large.

The biological data indicates that a change in water and/or habitat quality has likely taken place. All three biotic metrics indicate the occurrence of a small change at site M2 and a larger change at site M1. As stated previously, the author collected and identified the organisms on all of the samples from sites M1, M2, and M3. It is unlikely that the change is due to differences in time of collection, sampling gear, techniques, or taxonomic skill level. Additionally, the data points do not depict a random pattern. The metric scores have little scatter (the lone exception being the 1991 data from site M1) with a pronounced offset between years.

A change in the habitat at site M2 was quite apparent while performing the biological monitoring and habitat assessment field work. This change is discussed in detail in the next section. Briefly though, it appears that powerline right-of-way maintenance, resulted in many sections of streambank being denuded of vegetation (powerlines make more than 10 crossings on Otter Creek). The resultant erosion problems seem to have resulted in the measurable differences in biotic metrics between years.

It is fortunate that IDEM sampled these sites in 1991. Without the IDEM data, the 1994 data would probably have been accepted as pretreatment conditions. As the stream recovered from the habitat alterations, the improved biological integrity would have been attributed to the LARE project. Many false expectations could have been raised and many dollars wasted on a new miracle cure for water quality problems. Only to find out that replication of the treatment was never able to reproduce the same results.

It appears that the best estimate of pretreatment conditions is the 1991 IDEM data set. This data set is reflective of the biological integrity that existed prior to the recent alterations. There are reasons to expect that the stream will restore itself and return to its pre-alteration condition. After the streambanks have re-vegetated and the LARE project has had time to produce its effects, the macroinvertebrates can be resampled. If the LARE project was successful, the biotic metrics should be better than those of the 1991 samples.

Using the 1991 data alone to judge the success of the LARE project is problematic for two reasons. First it is dependent upon the assumption that the stream will fully recover from the habitat alterations. Since both of the 1991 sample sites in this area are in the impact zone of both powerline right-of-way maintenance and LARE project, it will be difficult to separate the effects of each. The second reason is the 1991 sample data set is small. The 1991 sampling by IDEM does not include field duplicates or an upstream control site like the 1994 data set has. Without field duplicates, it becomes difficult to estimate the variability in the pretreatment conditions. IDEM did perform lab duplicate procedures for site M1. However, lab duplicates only measure variability introduced by the subsampling technique. The M4 site is upstream and was sampled in 1991. However, it is too far upstream to serve as a good control site. More will be said about pretreatment conditions in the sections entitled "Pretreatment Conditions: Part II" (section 4.3.6) and "Pretreatment Conditions: Part III" (section 5.2.5).

4. HABITAT ASSESSMENT

The Goal of biological monitoring is to infer water quality. However, biological integrity is a function of both water and habitat quality. Since habitat quality can be exceedingly variable between sites or between the same site at different times, habitat quality must also be monitored. This section describes the habitat assessment results from the Otter Creek watershed and provides information relevant to the interpretation of pretreatment biological conditions.

4.1 Methods

Habitat assessment procedures were performed at site M3 following IDEM, OWM, BSS procedures (IDEM 1993). These procedures include the Ohio EPA Qualitative Habitat Evaluation Index (QHEI, Rankin 1989) and USEPA Habitat Assessment procedures (USEPA-HA, Plafkin et al 1989). The QHEI and USEPA-HA procedures were performed in 1991 by IDEM personnel at the sites M1, M2, and M4.

An attempt was made to assess changes in habitat quality between 1991 and 1994 at sites M1 and M2. In order to promote consistency with the 1991 habitat assessments at sites M1 and M2, copies of the 1991 forms were taken to these sites for re-assessment. Since some subjective interpretation is involved in the habitat assessment process, only those characteristics that had obviously changed were recorded in field notes. The intent of this procedure was to obtain scores approximating a score the original investigator would have given during re-assessment.

A photograph was taken of each site. At site M2, two additional photographs were taken to document vegetation removal on both up and downstream banks. Site photographs were taken on 4/3/95 (a time when foliage would not obstruct the surrounding landscape). Additionally, several photographs were taken to document general environmental conditions in Gundy, Swope, and Cox Ditches. On the day photographs were taken, very localized and intense thunderstorms had occurred earlier in the day. Skies were overcast. Light rain fell during most of the photography.

4.2 Results

Reproductions of habitat assessment forms for all sites assessed (both 1991 and 1994) in the Otter Creek watershed are included in Appendix B. The original 1991 habitat assessment forms are on file with the IDEM, OWM, BSS. The 1994 habitat assessment forms are on file with the author.

4.3 Discussion

The Habitat assessment discussion consists of several subsections. The first subsection (4.3.1) presents a descriptive assessment of the habitat at the four sites that have been sampled for macroinvertebrates on Otter Creek. The second (4.3.2) compares habitat quality as evaluated by USEPA and Ohio EPA methods at these sites. Comparisons of habitat assessment scores are made between Otter Creek sites and between Otter Creek and IDEM's macroinvertebrate reference sites. The third, fourth, and fifth subsections (4.3.3, 4, and 5) are descriptive assessments of habitat conditions in Gundy, Swope and Cox Ditches. A final subsection (4.3.6) incorporates habitat assessment information into an interpretation of biological monitoring pretreatment conditions.

4.3.1 Otter Creek

Many habitat characteristics at site M1 did not appear to have changed appreciably from 1991. As stated previously, the author was a member of the sampling team that sampled Otter Creek in 1991. Wide riparian zones of well-established woody vegetation were still present on both sides (figure 4.3.1-1). Instream habitat was provided by large woody debris. (Large woody debris alters the hydraulics of the stream creating small pools and riffles, alters substrate composition by scouring out sand and leaving gravel, and traps and concentrates organic materials in the eddies it creates.) Aside from riffle areas though, the majority of the stream substrate was composed of shifting sand which provides little habitat for macroinvertebrates. A gravel substrate was present in riffle areas, but in limited quantities only. The specific riffle sampled in 1991, although present, appeared to be somewhat degraded. As mentioned previously, a different riffle approximately 100 m upstream was judged to have superior substrate characteristics and was sampled instead.

Figure 4.3.1-1. Otter Creek at CR 24 West (view looking upstream, 4/3/95).

The habitat characteristics at site M2 appeared to have been radically altered. In 1991, the south bank had a dense stand of young (diameter less than three inches) trees. This is verified by the 1991 habitat assessment forms that indicates a thin 5-10 m riparian zone of woody vegetation. Additionally, the drawing of the stream channel on the same form indicates a much more complex instream channel morphology. However in 1994, the woody vegetation on the south bank had been removed (figures 4.3.1-2 and 4.3.1-3) and the instream channel morphology had been greatly simplified.

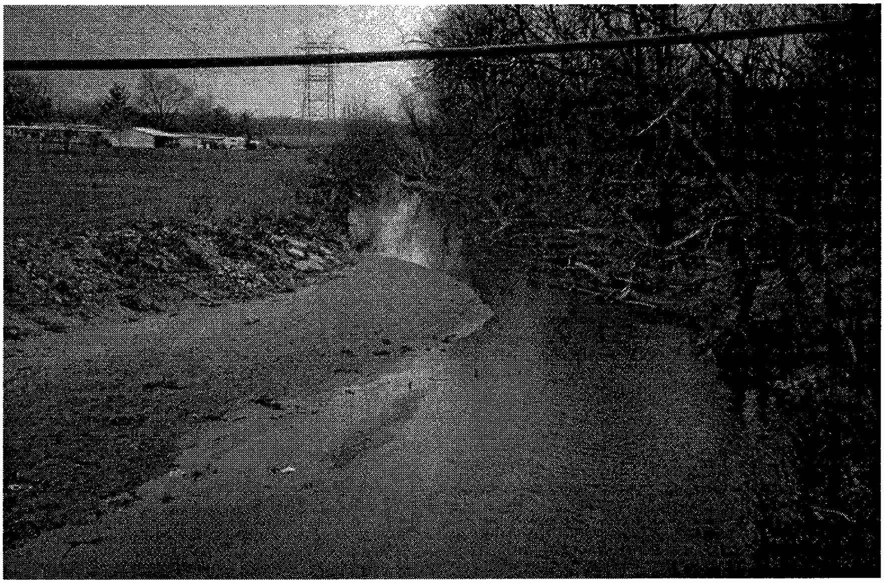

Figure 4.3.1-2. Otter Creek at Business 41 (downstream, 4/3/95).

The drastic changes in macroinvertebrate community structure may be related to powerline right-of-way maintenance. High-tension powerlines (background in figure 4.3.1-2 and extreme left of figure 4.3.1-4) cross Otter Creek in the vicinity of the biomonitoring sites. In fact, one powerline crosses Otter Creek nine times. The first crossing occurs approximately one mile upstream of site M1. The second crossing occurs at site M2. The same line crosses four more times between sites M2 and M3 and three more times upstream of site M3. It then crosses Sulfur Creek and several tributaries to Sulfur Creek. A second powerline crosses once on both Otter (upstream of site M3) and Sulfur Creeks. A third power line crosses Otter Creek near its mouth (downstream of site M1). Additionally, the second and third power lines make multiple crossings on Gundy and Cox Ditches (USGS 1962, USGS 1963). However, since little woody riparian vegetation exists along Gundy and Cox Ditches, it is likely little maintenance is performed here and impacts to water quality in this area due to power line maintenance should be minimal.

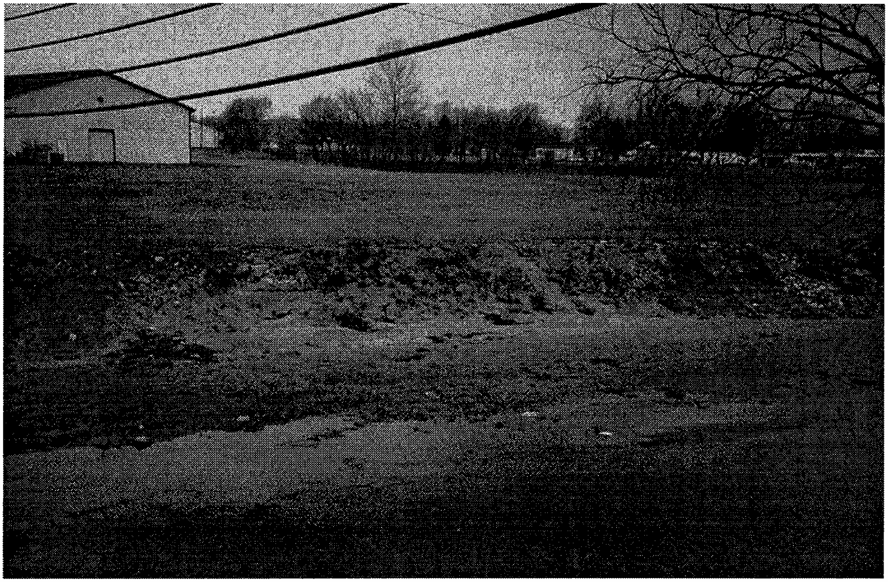

Figure 4.3.1-3. Otter Creek at Business 41 (downstream, 4/3/95) showing area of vegetation removal on south bank.

Figure 4.3.1-4 is a drawing of the business 41 (M2) sample area in 1991. It is taken from the Ohio EPA form that was filled out at the time of the 1991 sampling (appendix B). Compared to the photograph in figure 4.3.1-3, the sand bar on the stream's south-side has become larger and its shape simplified. The island that was present in 1991 was greatly diminished in 1994.

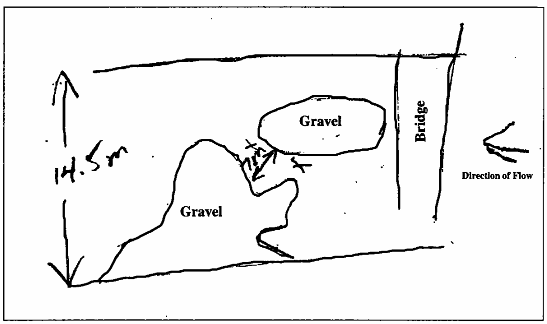

Figure 4.3.1-4. Drawing of stream channel downstream of business 41 in 1991 (Original artwork: Steven A. Newhouse).

It should be noted that only one powerline crossing could be observed. Other powerline crossings in this watershed take place in the middle of farm fields far from roadways. However, it is likely that powerline right-of-way maintenance is performed on all of the powerlines in an area at roughly the same time in order to minimize travel time for maintenance crews.

Additionally, the north bank upstream of the business 41 bridge was denuded of vegetation and partially covered with rip-rap. Rip-rap is the term for the white stones covering the upstream banks in figure 4.3.1-5. The stones are typically composed of limestone and are used to prevent streambanks from eroding away after vegetation removal. Rip-rap is typically thought to be innocuous and in some cases can provide habitat for certain sunfishes -- green sunfish, longear sunfish, and rockbass -- and macroinvertebrates (author's personal observation). However, there are several potential problems with rip-rap.

Figure 4.3.1-5. Otter Creek at Business 41 (upstream, 4/3/95) showing rip-rap and lack of woody vegetation.

Tree-lined banks, in comparison to rip-rapped banks, provide shade, organic material, and large woody debris to streams. Direct sunlight on a stream can promote algal growth and causes water temperatures to fluctuate beyond their normal daily extremes. Increases in algal growth cause changes in aquatic community structure that promotes herbivorous organisms at the expense of other organisms. Accentuated water temperature fluctuation favors organisms that are less sensitive to heat changes than the original biota. Trees provide shade to a stream's surface which reduces both temperature extremes and algal growth. A tree's annual leaf-fall provides organic material that feeds detritivorous organisms. Replacement of the trees with rip-rap will reduce the number and diversity of detritivorous organisms. Removing the large woody debris source (branches and whole trees that fall into the stream from its banks) removes the best habitat structure in the streams of the Otter Creek watershed. Without large woody debris inputs, the instream habitat of most of Otter Creek and its tributaries would consist of shallow water over a monotonous substrate of shifting sand.

Fallen trees and other debris change the local water currents. Large woody debris causes constrictions in stream channels that increase water velocity. Changes in water velocity create gravel raceways through the selective removal of sand and smaller substrate materials and change substrate contours to create deep pools and shallow riffles. Behind fallen logs, on the other hand, water velocities may be diminished creating depositional areas that can be rich in organic materials. Other than a few areas of bedrock outcrop in this watershed's streams, it is large woody debris that creates diverse habitat conditions that can be occupied by a diverse assemblage of organisms.

Another problem with rip-rap is financial liability. The individual stones in rip-rap are usually loose and roll or twist when stepped on. It is easy for a person to be seriously injured traversing a steeply angled bank laced with rip-rap. The original woody vegetation the rip-rap replaced provided several hand-holds and support. Not only does the rip-rap provide no hand-holds and little support, rip-rap tends to prevent woody vegetation from returning. Therefore, rip-rapping a bank ensures the liability will exist for years to come. Since the stream itself is legally considered an attractive nuisance, the addition of rip-rap seems ill-advised at best.

One attempt to secure rip-rap in place the author has observed at several rip-rapped sites is to splash a small amount of concrete on top of the rip-rap. The hardened concrete prevents the rip-rap from moving or washing away as readily. However, the uneven and actually jagged edges of the hardened concrete do not seem to present a much diminished hazard or liability. Additionally, the hardened concrete prevents the re-establishment of vegetation for an even longer period of time, therefore possibly extending the length of time the liability exists.

Finally, one last potential problem with rip-rap deals with its chemistry. Limestone varies along a gradient from almost pure calcium carbonate to dolomite which has magnesium substituted for a large proportion of the calcium (calcium-magnesium carbonate). It is the author's understanding that rip-rap which is excavated from quarries tends to be more calcium-rich, whereas, limestone that is present at the surface tends to be weathered to the more dolomitic (magnesium-rich) form. It is likely that ions from rip-rap in contact with stream-water dissolve into solution and alter water chemistry slightly. This process probably continues until the rip-rap dissolves, or more likely, forms a weather-resistant dolomitic surface layer through ion exchange with stream-water and/or selective removal of calcium ions from the rip-rap's surface. (Selective calcium ion removal will result in a build-up of the concentration of magnesium ions that occurred naturally at lower concentrations in the unweathered rip-rap.)

Seemingly, changes in water chemistry would be small and any effects on aquatic biota negligible. However on several occasions, the author has had electro-fishing equipment overload in the vicinity of recently deposited rip-rap. (Electro-fishing equipment sends an electrical charge through water in order to stun fish for fisheries surveys.) Moving equipment upstream of the rip-rap and restarting it often resulted in remediation of the problem.

The author attributed the electrical overload to rip-rap. The idea being the rip-rap's presence resulted in an increased ionic concentration. A higher ion concentration increased the water's conductivity that resulted in an overloaded electro-fishing unit when more current returned to the unit through its cathode. Admittedly, the particular electro-fishing unit is old and suffers from multiple afflictions. Possibly, the observed correspondence between rip-rap and overloads is coincidental. However, considering that aquatic organisms are extremely sensitive to electrical fields and chemical gradients, there does appear to be some potential for impacts to aquatic communities. In summary, considering the potential environmental impacts to water chemistry, as well as the aforementioned thermal, eutrophic, physical habitat, and liability problems, alternative erosion control measures should probably be considered.

A better way to control erosion on streambanks without the use of rip-rap might be to use willow posts to secure streambanks. The Missouri Department of Conservation recommends this method and has produced brochures and videotapes that describe this method in detail. The method involves driving posts recently cut from willow trees into the streambank. The posts will quickly sprout roots and leaves and secure the bank from erosion. In addition to controlling erosion, willow trees tend to grow out and over a stream, and therefore, even small willow trees can provide shade to the water's surface. Since willows do not grow as tall as some tree species, the willows may not become problems under power lines. If natural willow species grow too tall, dwarf varieties may be available. Simply finding vegetation that does not require removal as often or selectively killing vegetation and leaving the dead wood standing to protect banks would help. If these trees require little or no maintenance, this erosion control measure may benefit water quality while saving the utility company, and its customers, money.

Further upstream is site M3. It is located just downstream from the Old Mill Dam (figure 4.3.1-6). The mill dam is the centerpiece of a small park. Trees line the north bank. The south bank is mostly mowed grass. The instream habitat at this site is radically different from that at sites M1 and M2. The substrate is a bedrock outcrop.

Figure 4.3.1-6. Otter Creek at Old Mill Dam (upstream, 4/3/95).

The 1991 habitat assessment form for site M4 is included in appendix B. However, the site is located too far upstream on the North Branch Otter Creek to be useful in this study. The site was not revisited to determine if habitat characteristics had changed. Results of its Ohio and USEPA habitat assessment scores are used in the next subsection for comparative purposes only.

4.3.2 Ohio and USEPA Habitat Assessment Methods

Ohio EPA and USEPA have established methods to consistently assess habitat characteristics of streams and rivers. These methods consist of assessing a series of habitat characteristics and assigning a numerical rating according to rather rigid guidelines established for each method. Guidelines are defined as rigidly as possible in order to remove as much subjective interpretation as possible. Typically, an environmental scientist evaluates habitat according to a standardized form while standing in the middle of the stream of interest. Copies of 1991 IDEM and 1994 LHR habitat assessment forms for sites M1 through M4 are included in appendix B.

Figure 4.3.2-1 depicts the USEPA habitat assessment scores for the four Otter Creek sites. The best habitat according to this method is at site M3 (1994) and M4 (1991). Site M1's score did not change between 1991 and 1994. Although some negative changes (substrate quality and pool depth) have occurred between 1991 and 1994 at this site, there were some habitat characteristics (bank stability) that are better at the 1994 location (100 meters upstream) than the 1991 location. Site M2 is the business 41 site which has had much of its riparian vegetation removed for powerline right-of-way maintenance. The USEPA score lost 19 points at this site. Changes occurred in the following characteristics -- bottom substrate (-2), embededness (-2), velocity/depth (-2), channel alteration (-1), bottom scouring (-1), pool/riffle ratio (-4), bank stability (-5), and streamside cover (-2) characteristics.

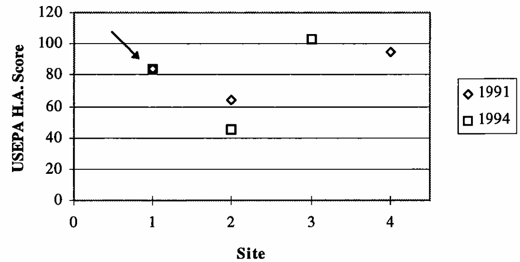

Figure 4.3.2-1. Comparison of USEPA habitat assessment scores (arrow indicates the same value for 1991 and 1994). Higher is better.

USEPA percentile ranks (figure 4.3.2-2) show more dramatically that sites M1 and M2 have lower habitat quality than sites M3 and M4. Site M2 in 1991 had one of the lowest USEPA habitat scores in IDEM's reference site data set. The 1994 score places this site below all habitat scores in IDEM's data set. Had IDEM's macroinvertebrate survey for this area been performed in 1994, this site probably would not have been chosen as a reference site. According to USEPA methods, site M2 may not have belonged in the reference data set in even in 1991.

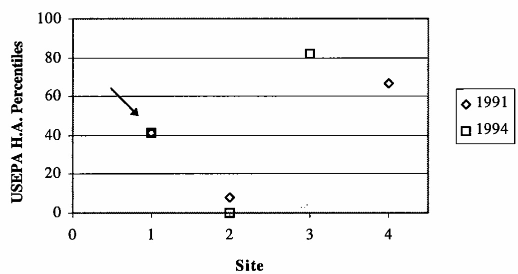

Figure 4.3.2-2. Comparison of USEPA habitat assessment percentile ranks (arrow indicates the same value for 1991 and 1994). Higher is better.

Ohio EPA scores (figure 4.3.2-3) show a similar distribution to the USEPA scores. Sites M3 and M4 received the highest scores. Likewise, M1 and M2 received the lowest. Site M1 lost three points according to Ohio EPA habitat assessment methods between 1991 and 1994. Changes occurred in substrate quality (-1), instream cover (-1), and riffle quality (-1) characteristics. Site M2 lost nine points. Changes occurred in instream cover (-2), channel morphology (-1), riparian zone (-1), bank erosion (-2), pool quality (-2), and riffle quality (-1) characteristics.

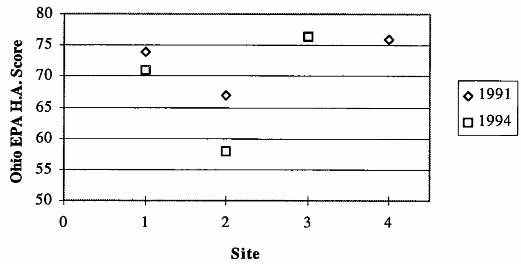

Figure 4.3.2-3. Comparison of Ohio EPA habitat assessment scores. Higher is better.

Ohio EPA percentile ranks (figure 4.3.2-4) are higher than USEPA percentiles (figure 4.3.2-3). The 1991 Ohio EPA scores for sites M1 and M2 were both in the upper 50% of IDEM reference sites. On the other hand, the 1991 USEPA scores for both of these sites were in the lower 50% of IDEM reference sites. Possibly, USEPA habitat assessment methods score more negatively for sites with sand substrates. However, both habitat assessment procedures suggest site M2 has declined in habitat quality between 1991 and 1994. The Ohio EPA methods suggest that habitat degradation has also occurred at site M1 to a lessor extent.

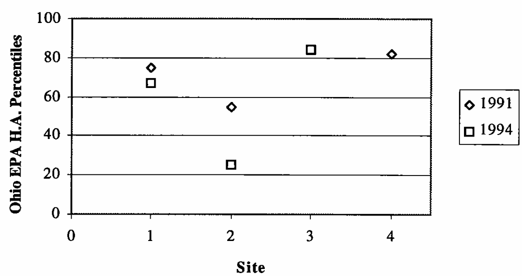

Figure 4.3.2-4. Comparison of Ohio EPA habitat assessment percentile ranks. Higher is better.

Many of the changes at site M2 are readily explained by the vegetation removal associated with powerline right-of-way maintenance. If trees are removed, it is obvious that bank stability, riparian zone quality, and bank erosion characteristics will change. However, changes in instream substrate and instream cover quality occurred at both sites for which change could be assessed.

The changes in substrate and pool depth suggest that large quantities of sediment and sand have been introduced into the stream. The bare soils on the south bank downstream of

Business 41 at site M2 and the vegetationless rip-rapped banks upstream of Business 41 seem a likely source of sediment. If it is assumed that many of the powerline right-of-way crossings were left in similar condition, the changes in Otter Creek may possibly be explainable by this one phenomenon alone.

This one phenomenon, however, appears to caused changes in Otter Creek's substrate and pool depth for many river miles. Substrate and pool changes occurred at site M1 which is more than three quarters of a mile downstream from the nearest powerline crossing. Assuming streambank structure is severely degraded at the individual powerline crossings, the denuded banks probably suffer severe erosion creating a water quality problem. Sedimentation from the water carrying the eroded material would fill in pools and smother gravel runs with sand and smaller particles creating additional habitat problems throughout the waterway.

Normally, vegetation removal from powerline right-of-ways would not cause such severe problems. However, soils in this area are extremely sandy and appear to be deficient in nutrients and organic material. Possibly after vegetation removal, it is difficult to re-establish vegetation due to streambank physical and nutritional characteristics.

In the last subsection, Otter Creek habitat quality was examined in detail using formal habitat assessment procedures. In the next three subsections, environmental conditions in the vicinity of Cox Ditch are examined. Ditches in this area contain, undoubtedly, the worst habitat in the entire Otter Creek watershed. Since no macroinvertebrate samples could be collected from these ditches, no formal habitat assessment procedures were followed. (Habitat assessment procedures describe the habitat at a particular site, usually a sample site.) The descriptive assessment approach used earlier in section 4.3.1 is followed to convey the environmental condition over a larger aerial extent. Figure 4.3.2-5 will help identify sites in this sections 4.3.3, 4, and 5.

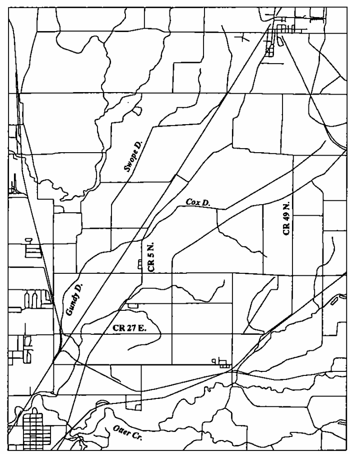

Figure 4.3.2-5. Map of Gundy, Swope, and Cox Ditches.

4.3.3 <u>Gundy Ditch</u>

Gundy Ditch collects water from both Swope and Cox Ditches and conveys it to Otter Creek. In figure 4.3.3-1, Gundy Ditch follows a railroad track. The ditch has little to no meanders. The east-side (right bank in figure 4.3.3-1) is developing a woody riparian zone. The west-side (left bank) is probably cut or sprayed with herbicides to prevent trees from growing up into the telephone lines or for railroad right-of-way maintenance. Instream habitat is negligible. Substrate is composed of shifting sand and some trash. If the vegetation on the east-side of the ditch is allowed to mature, large woody debris from branches and trees falling into the water will eventually provide habitat for fish and macroinvertebrates.

Figure 4.3.3-1. Gundy Ditch at CR 27 East (upstream, 4/3/95).

Downstream from this site, Gundy Ditch cuts through the front yard of a residence. No woody vegetation is allowed to grow on either bank and grass is mowed to the streambank edge. These landscaping techniques have resulted in streambank failures (large masses of soil and attached vegetation breaking free from the streambank) that contribute large quantities of sediment directly to the stream channel.

The habitat and environmental quality of Gundy Ditch change over its length more so than in either Swope or Gundy Ditches. At the upstream end of Gundy Ditch, the ditch is straight and lacks vegetation. It is merely a continuation of the poor habitat and environmental quality found in Swope and Cox Ditches. However, further downstream, woody riparian vegetation becomes more common. Near its confluence with Otter Creek, its natural meanders have been preserved.

4.3.4 Swope Ditch

Swope Ditch (figure 4.3.4-1) is a hydraulic engineer's fantasy-come-true and an aquatic ecologist's nightmare. From the engineer's perspective, a straight ditch occupies the least land area and drains water quickly. The absence of woody vegetation allows easy access for channel maintenance. The grass (a non-native species) holds the ditch banks in place while allowing water to infiltrate through the bank. From the aquatic ecologist's perspective, the ditch is practically sterile. The lack of variation in habitat means few species will reside in this ditch. Compounding the problem for aquatic life, the quick water drainage means steamflow conditions vary from floodwaters during a storm to complete desiccation between rain events.

Figure 4.3.4-1. Swope Ditch at CR 47 East (upstream, 4/3/95).

Looking downstream from figure 4.3.4-1, there was an accumulation of trash and old auto parts in the stream channel. Trash was a common site in all of the ditches in the Gundy Ditch drainage area.

The water quality and aquatic biota of Otter Creek are impacted by conditions in its tributaries. Since farm fields line Swope Ditch instead of trees, agricultural chemicals pass from fields to waterway without the filtering effect that trees and their extensive root systems provide. Without shade from trees, the water that passes through Swope Ditch has elevated temperature and algal cell concentrations. Without habitat and consistent water flow in Swope Ditch, small fish are left without stable headwater stream habitats in which they can avoid predation by larger fish.

The author is not implying that Swope Ditch should be restored to its original conditions to the local farmer's detriment. If the predominance of local land usage is any indication of that land use's utility to society, then Swope Ditch's predominant function should be to convey water from the adjacent agricultural fields. However, Swope Ditch is connected hydrologically to Otter Creek. Decisions made regarding Swope Ditch impact Otter Creek water quality and biota. Ideally, impacts to Otter Creek should be factored into the decision-making process for Swope Ditch.

The reason these impacts are not a consideration to many land owners is that it does not pay many of the land owner's to protect water quality and biota. Typically, the benefits of good water quality and biota increase as a stream gets larger. Small tributaries are important to water quality. However, the benefits from headwater stream protection (clean water for drinking or swimming, good fishing, etc.) occur many miles downstream from the landowners who own the headwaters. This spatial separation of benefits of stream protection from costs of stream protection in stream headwaters is, arguably, the greatest cause of water quality degradation.

The spatial separation of costs and benefits implies there should be some mechanism to compensate upstream landowners to protect streams. Ideally, downstream landowners who enjoy benefits of improved water quality and biota could rent or buy conservation easements adjacent to headwater streams. The conservation easements would be allowed to re-vegetate. In order for this system to work, the downstream landowners would need to be assured that the conservation easement would not be channelized. One of the reasons downstream landowners do not do this is most downstream landowners do not appreciate their stream's value. This lack of appreciation or value is addressed later at the end of section eight.

4.3.5 Cox Ditch

Cox Ditch (figure 4.3.5-1) was different from Swope Ditch in many respects. Although this waterway is a channelized ditch, the ditch was recovering from the effects of the previous channelization. One side of the ditch was lined with a thin band of young trees. Additionally, the stream channel was beginning to form meanders. Meanders create differential flow velocities in the stream, produce variable stream depths, slow overall water velocity, improve habitat quality, and eventually produce more stable water flow regimes.

Figure 4.3.5-1. Cox Ditch at CR 5 North (upstream, 4/3/95). At the time of the photograph, vegetation was being removed from the right (east) bank and a dredge (a piece of heavy equipment used to "dredge-out" or channelize a stream) was observed in the distance adjacent to the stream.

As a ditch looses its channelized characteristics and reverts to a more natural morphology, the waterway begins to occupy more of the space that crops could occupy. Additionally, woody riparian vegetation can out-compete adjacent crops for light and water. Since, natural channel conditions are perceived as expenses to local landowners, drainage boards are pressured into spending public funds to re-channelize. If headwater landowners could sell or rent riparian lands to downstream landowners, there would be less pressure to re-channelize.

During the author's last visit to Cox Ditch, it was being re-channelized. Only some vegetation removal had occurred at the site in figure 4.3.5-1. The photograph shows mostly pre-channelization conditions. The post-channelization conditions will more closely resemble Swope Ditch (figure 4.3.4-1).

Figure 4.3.5-2 is further upstream on Cox Ditch. It should be pointed out that there is no water in Cox Ditch at this point. The streambed was dry downstream for as far as the author could see. Upstream from this point, there was standing water with some emergent aquatic plants growing in it.

Figure 4.3.5-2. Cox Ditch at CR 49 North (downstream, 4/3/95). The dark horizontal objects lying in the farm fields adjacent to the channel are newly felled trees stacked into piles (arrow).

It is the author's understanding that this is the general area where the proposed land treatment is to take place. It is obvious the water quality and biological integrity improvements the LARE project seeks would have to be found far downstream. Similar to Swope Ditch and parts of Gundy Ditch, some locations on Cox Ditch are strewn with trash and old auto-parts.

In both figures 4.3.5-2 and 3, the extent of the vegetation removal on Cox Ditch can be seen. The channelization of this ditch, undoubtedly, resulted in greater environmental disruption than any environmental benefits the LARE project will produce. The denuded streambanks, exposed to erosion after reshaping, will contribute massive quantities of sediment to Otter Creek. Even after a grass layer returns to the banks, clumps of grass and soil will continuously slough off and into the channel to be carried downstream to Otter Creek.

Figure 4.3.5-3. Vegetation removal on Cox Ditch at CR 49 North (downstream, 4/3/95). The dark horizontal objects lying in the farm fields adjacent to the channel are newly felled trees stacked into piles (arrow).

4.3.6 Pretreatment Conditions: Part II

The biological monitoring and habitat assessments performed in 1991 aid tremendously in the interpretation of the 1994 data. The combined IDEM and LHR data suggest Otter Creek water and habitat quality is probably dependent upon time. Best conditions probably occur just before powerline right-of-way maintenance takes place with worst conditions immediately afterward. In the years between powerline maintenance projects, the water and habitat quality and biotic communities slowly recover.

Ohio and USEPA habitat assessment methods were useful because of the qualitative information they contain. The important information from methods is that there was a change at sites M1 and M2. As will be seen at the end of the next chapter, the quantitative abilities of these methods leave something to be desired.

5. LAND USE ANALYSIS

Chapter 5 evaluates the LARE project's potential for success (from the standpoint of biological improvement), makes recommendations for the project's improvement, and finishes the evaluation of pretreatment conditions in the Otter Creek watershed. This chapter examines spatial relationships between land uses in the Otter Creek watershed and their potential impacts to the water quality and biota of this watershed.

Land usage impacts water quality and biological integrity. Tremendous differences are expected in both water quality and biological integrity in watersheds that differ greatly in land usage. However, it is rare for land usage to be seriously considered in water quality surveys.

An analysis of the Otter Creek watershed's land use was performed in order to determine the extent to which Cox Ditch's land usage impacts the water quality of Otter Creek. In this chapter, several different methods for determining the impact of land use on water quality will be compared. Although much valuable information can be acquired through each one of these methods, by the end of this chapter it will be clear that many of them are poor estimators of water quality impacts. The point of this chapter is that the typical method of estimating land use impacts to water quality is conceptually flawed and inaccurate.

The first three analyses use a model of land use impact to water quality that many environmental scientists typically, though often less formally, use. Often when asked about the extent that land usage impacts water quality in a particular watershed, environmental scientists respond in terms of estimated percentages of the surface area of a watershed covered by individual land uses. Towards the end of this chapter, a superior method that accounts for land use position relative to a watershed's drainage system is used. Using this method it was possible to accurately model potential impacts of land uses to water quality and identify sites in Otter Creek watershed that have a high potential to degrade water quality due to their position within this watershed.

5.1 Methods

In order to determine the land usage of a watershed, the watershed must be delineated. The Otter Creek watersheds were delineated based a 30 m × 30 m digital elevation model in geographic information system. This method uses topographic information to delineate watersheds in much the same way a human with a pencil and topographic maps would. However, this method is more accurate and less subjective. Land use data came from the USGS land use data analysis (LUDA) files. This land use data has a resolution of 200 m × 200 m. The land use data is from 1979.

5.1.1 Total Watershed Land Use

The first method calculates land use percentages based upon the entire watershed. Three separate watersheds were examined -- Cox Ditch, Gundy Ditch, and Otter Creek. The watersheds are nested within each other. Since the difference between these nested watersheds is the information of interest, land use percentages were calculated for each watershed without the nested watersheds of interest. In other words, Otter Creek percentages are for all of Otter Creek exclusive of the entire Gundy Ditch watershed. Gundy Ditch watershed percentages are calculated for all of Gundy Ditch's watershed excluding the Cox Ditch watershed. Cox Ditch has no watersheds of interest nested within it, therefore Cox Ditch percentages are calculated for the entire Cox Ditch watershed. Additionally, entire Otter Creek watershed percentages (including nested watersheds) were calculated for comparative purposes.

5.1.2 Visual estimation

The second method uses maps to convey changes in the spatial distribution of land uses from one part of a watershed to another. Each map shows the distribution of one land use throughout the watershed. The streams are overlaid on the map to serve as landmarks only. This method requires visual estimation of differences in land use proportions. Only the three major land uses in the Otter Creek watershed -- residential, cropland and pasture, and forestland -- will be depicted in this manner.

5.1.3 Surface Area Model

The third method uses maps similar to the second method. These maps depict land use percentages for each point on a stream. The stream color (shading in black and white) indicates land use percentage upstream from that point. Also similar to the second method, only one land use is depicted on a map. This method of modeling impacts to water quality and biological integrity on the percentage of watershed surface area occupied by a land use will be referred to simply as the "surface area model" or "method". The following equation is used to determine land usage by the surface area model:

$$LU_x = \frac{\sum_{i=1}^{n}(B_i \times A_i)}{\sum_{i=1}^{n} A_i} \times 100 \qquad 9.1\text{-}1$$

where:

LU_x = the percentage of a given land use at a particular point, x, in the watershed;
n = the number of cells upstream of point, x, in the watershed;
B_i = a dummy variable that equals 1 if the cell, i, is classified as the land use of interest, or equals 0, if the cell is not classified as the land use of interest; and
A_i = the area of a given cell. Since all cells are the same area, A_i always equals 900 m^2 (30 m $\times$ 30 m) in this analysis.

5.1.4 Water Volume Method

The last two models used in this chapter use water volume passing through a cell to determine impacts to water quality. The volume of water that passes through a cell, i, is defined as:

$$Vol_i = \sum_{j=1}^{n}(A_j \times W) \qquad 10.1\text{-}1$$

where:

Vol_i = the volume of water that passes through cell, i, in a typical year;
n = the number of cells upstream of point, i, in the watershed;
A_j = the area of a given cell. Since all cells are the same area, A_j always equals 900 m^2 (30 m $\times$ 30 m) in this analysis; and
W = the vertical depth of water that each cell contributes as runoff in a typical year.

W is considered to be a constant in this analysis and will not be discussed further since it cancels out in both equations 10.1-2 and 3.

Potential impacts were determined by equation 10.1-1. It has the same form as equation 9.1-1 with the exception that Vol_i (the volume of water) substitutes for A_i (the watershed surface area).

$$LU_x = \frac{\sum_{i=1}^{n}(B_i \times Vol_i)}{\sum_{i=1}^{n} Vol_i} \times 100 \qquad 10.1\text{-}2$$

where:

LU_x = the percentage of a given land use at a particular point, x, in the watershed;
n = the number of cells upstream of point, x, in the watershed;
B_i = a dummy variable that equals 1 if the cell, i, is classified as the land use of interest, or equals 0, if the cell is not classified as the land use of interest; and
Vol_i = the volume of water that passes through cell, i, in a typical year;

5.1.5 Damage Potential

Potential to degrade water quality was determined by equation 10.1-3. This equation is simply the sum of dilution ratios. It assumes that water quality degradation is proportional to the volume of water that interacts with (flows through) a cell.

$$DP_x = \sum_{i=1}^{m} \frac{Vol_x}{Vol_i} \qquad 10.1\text{-}3$$

where:

DP_x = the damage potential of a 900 m^2 parcel of land (cell) at a particular point, x, due to its position in the watershed;
m = the number of cells downstream of a point, x, in the watershed;
Vol_x = the volume of water that passes through cell, x, in a typical year;
Vol_i = the volume of water that passes through cell, i, in a typical year;

Since this analysis is only concerned with the Otter Creek watershed, m (the number of cells downstream of x) ends at the mouth of Otter Creek. No consideration is given to water quality degradation in the Wabash River or other downstream waterways.

5.2 Results and Discussion

Five land use impact assessment methods were performed. The results of each of the five methods, as well as the third part of the pretreatment conditions discussion (section 5.2.5), will be discussed in separate subsections.

5.2.1 Land Use Impacts as a Function of the Entire Watershed Area

The first method uses the land usage of the entire watershed to estimate the land usage that would impact each site of interest in the watershed. Table 5.2.1-1 compares the proportions of the land uses within the Otter Creek watershed and selected sub-basins. The results of the land use analysis are presented for three portions of the Otter Creek watershed, as well as, Otter

Creek watershed in its entirety. Cox Ditch (figure 5.2.1-1a) results are presented for this watershed in its entirety. Gundy Ditch (figure 5.2.1-1b) results are presented for the Gundy Ditch watershed excluding Cox Ditch. Similarly, the results referred to as Otter Creek (figure 5.2.1-1c) reflect the land usage in the Otter Creek watershed excluding Gundy and Cox Ditches. Finally, the results referred to as "entire watershed" include land uses for the entire watershed.

Table 5.2.1-1. Comparison of land usage (in acres and as a percentage of the respective watershed) within the Otter Creek watershed and some of its selected sub-basins.

USGS Land Use Classification*	Cox Ditch[a]	Gundy Ditch[b]	Otter Creek[c]	Entire Watershed[d]
Residential	18.5ac.(0.49%)	179.03(2.44)	3640(5.33)	3840(4.81)
Commercial and Services	-	17.4(0.24)	285(0.42)	302(0.38)
Industrial	-	-	114(0.17)	114(0.14)
Transportation, Communications, and Utilities	-	-	62.3(0.09)	62.3(0.08)
Industrial and Commercial Complexes	-	-	152(0.22)	152(0.19)
Mixed Urban or Built-up Land	-	-	106(0.16)	106(0.13)
Other Urban or Built-up Land	-	-	215(0.31)	215(0.27)
Total Urban/Suburban Land Uses:	**18.5(0.49)**	**196(2.67)**	**4580(6.69)**	**4790(6.00)**
Cropland and Pasture	3850(95.8)	6970(94.9)	38,700(56.5)	49,500(62.0)
Deciduous Forest Land	149(3.71)	178(2.43)	23,900(34.9)	24,200(30.3)
Reservoirs	-	-	31.1(0.05)	31.1(0.04)
Strip Mines, Quarries, and Gravel Pits	-	-	1280(1.87)	1280(1.60)
Transitional Areas	-	-	24.9(0.04)	24.9(0.03)
Total Rural Land Uses:	**4000(99.5)**	**7150(97.3)**	**63,800(93.3)**	**75,000(94.0)**
Total All Land Uses:	**4020(100)**	**7350(100)**	**68,400(100)**	**79,800(100)**
Watershed Area as a Percentage of the Entire Watershed Area	5.04%	9.21	85.8	100

* (USGS 1979)

[a] Cox Ditch watershed in its entirety (figure 9.2.1-1a).

[b] Gundy Ditch watershed excluding Cox Ditch watershed (figure 9.2.1-1b).

[c] Otter Creek watershed excluding the entire Gundy Ditch watershed (Gundy and Cox watersheds, figure 9.2.1-1c).

[d] Entire Otter Creek watershed (including Gundy and Cox Ditch watersheds).

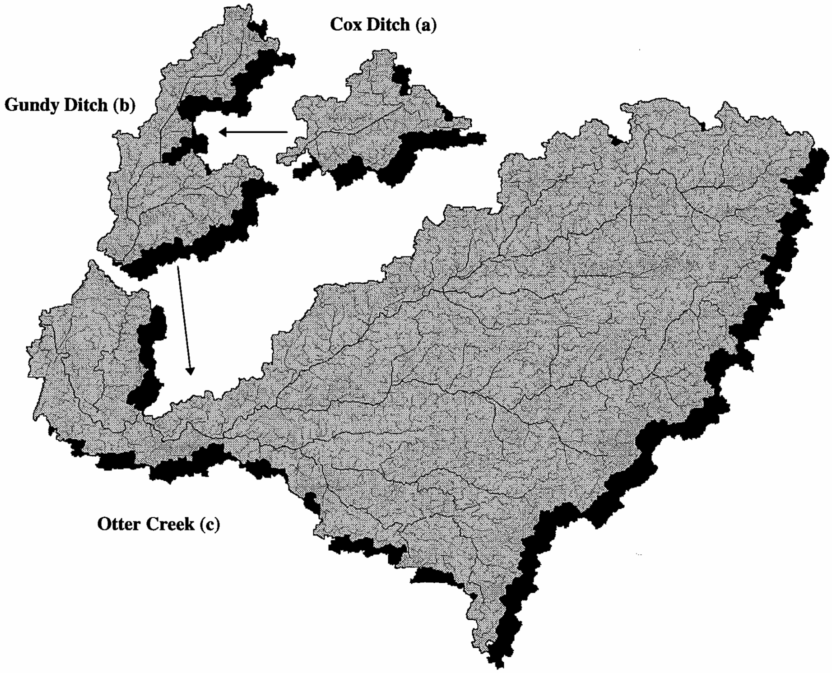

Figure 5.2.1-1. Exploded view of Otter Creek watershed depicting (a) Cox Ditch watershed, (b) Gundy Ditch watershed excluding Cox Ditch, and (c) Otter Creek watershed excluding Gundy and Cox Ditch watersheds. Arrows indicate actual positions.

As table 5.2.1-1 shows this method can reveal some tremendous differences in land use characteristics of watersheds. Otter Creek watershed excluding the Gundy Ditch watershed is only 56.5% cropland and pasture compared to 95.8% for Cox Ditch. Cox Ditch watershed is only 3.71% deciduous forest land compared to 34.9% (almost an order of magnitude difference) for Otter Creek excluding the Gundy Ditch watershed. Assuming that agricultural land uses tend to degrade water quality and forestland tends to improve water quality, Otter Creek should have better water quality and biological integrity than Cox Ditch (when Cox Ditch has water in it).

The USGS (1979) data set lumped cropland and pasture land uses into the same category. This makes it impossible to analyze these land uses separately. This is unfortunate since these land uses may have quite different effects on water quality. Since all of the methods presented in this chapter use the same land use data, all of the models are equally effected by this problem.

It is not uncommon for land use data to be reported by environmental agencies in this manner. In reports, several sites may be sampled in a watershed. However, only one set of land usage estimates is included. Typically, the land use estimates are for the entire watershed.

One problem with this method is that land usage percentages are reported as equal for all samples taken in the watershed. However, if all of the sample sites are not at the outlet of the watershed, some of the land uses will occur downstream of the sample sites. Impacts from downstream land usage would not effect sites upstream. Since, land usage is often related to watershed size. (For example, cities often occur on streams and rivers of some size rather than on headwater streams.) The inclusion of the downstream land use data decreases the accuracy of this method.

5.2.2 Spatial Distribution of Land Uses

The second method uses maps to depict the land usage impacting a site. The person interpreting the map can judge which land uses are above each site. Estimates of forestland in a watershed are commonly done using USGS topographic maps. Often this information is not recorded, but is used for site selection. The following maps show the spatial distribution of the three major land uses in the Otter Creek watershed and sub-basins. Streams are marked on the map to provide reference points only. Much can be learned from this method as the following maps show.

Residential land usage (figure 5.2.2-1) tends to be confined to a small region in the lower (downstream) portion of the Otter Creek watershed just north of Terre Haute, IN, an area on the west-side of Brazil, IN, and some small towns between Brazil and Terre Haute (Seelyville and Staunton, IN). In the lower portion of Otter Creek's watershed, residential land use tends to encroach on major drainage-ways. On the other hand, in the upper reaches of the same watershed, residential areas are located away from major drainage-ways. Topographic differences explain this phenomenon. The lower reaches of Otter creek watershed are flat. The upper

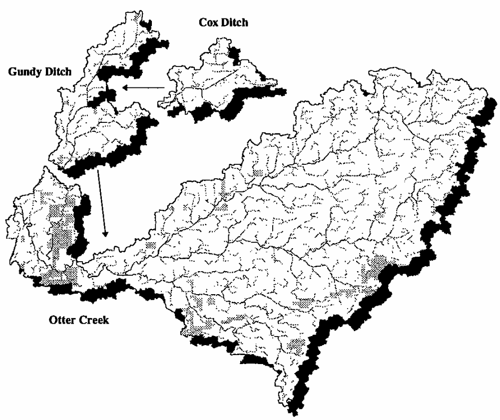

Figure 5.2.2-1. Residential land usage (shaded) in relation to the streams and sub-basins of Otter Creek.

reaches have greater topographic relief, especially near stream channels. Since flat land is desirable for residential areas, this land use does not encroach on streams in the upper watershed.

The point that topography greatly impacts land use is even more dramatically illustrated in figure 5.2.2-2 which depicts the distribution of agricultural lands. In the upper watershed, agricultural land uses occupy the ridge tops. Stream valleys do not have wide enough floodplains and valley sides are too steeply sloped to permit agricultural land usage. On the other hand, agricultural land uses encroach on the stream channels in the lower Otter Creek, Gundy, and Cox Ditch watersheds due to this area's diminished topographic relief.

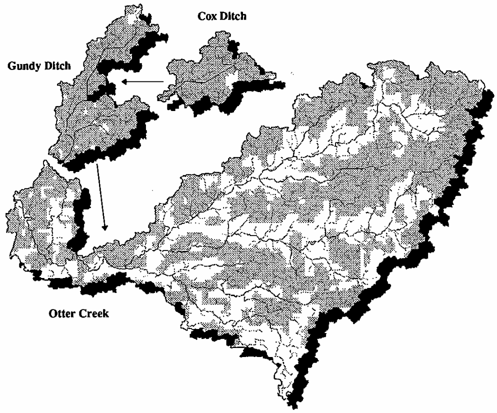

Figure 5.2.2-2. Cropland and pasture land usage (shaded) in relation to the streams and sub-basins of Otter Creek.

Forestlands (figure 5.2.2-3) have been relegated to the steep slopes and thin floodplains of Otter Creek's upper reaches. This distribution of forestlands explains the good water quality and biological integrity characteristics of Otter Creek. The tree-lined streams are, to some degree, protected from residential and agricultural impacts.

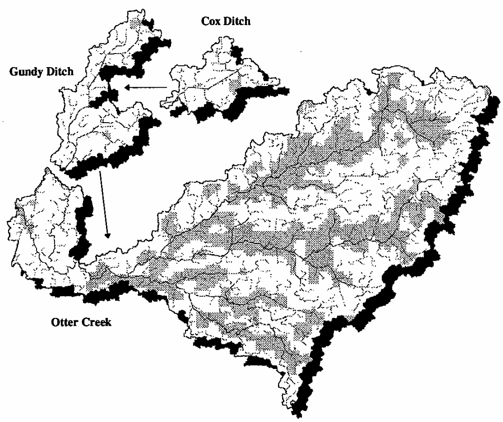

Figure 5.2.2-3. Forestland (shaded) in relation to the streams and sub-basins of Otter Creek.

A lot of information can be learned from this method. The most valuable information involved the spatial relationships between waterways and land uses. However, this method is to a high degree subjective and descriptive. It would be hard to convey this information without simply showing the maps to another person and hoping they come up with the same subjective interpretation.

5.2.3 Surface Area Model of Land Use Impact to Water Quality

This next method uses maps in a much more quantitative way. The following maps depict the percent residential, cropland and pasture, and forestland upstream from each point on the streams of the Otter Creek watershed. The color (shade) of the streams indicates the percentage of watershed surface area occupied by a particular land use.

Most of the Otter Creek watershed is not impacted by residential land usage (figure 5.2.3-1). Residential land use only accounts for a significant proportion of water quality impacts in small tributary streams directly adjacent to residential areas. In this watershed, residential land use does not have a significant impact on water quality.

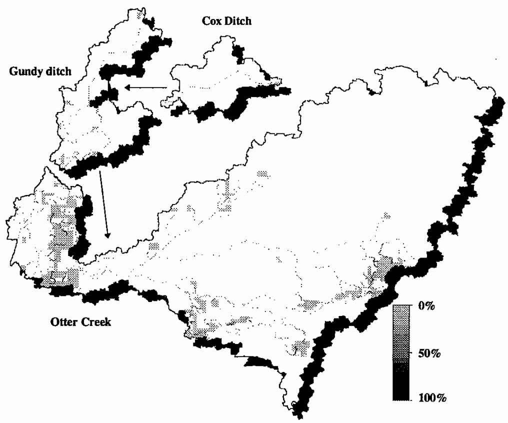

Figure 5.2.3-1. Percent residential land usage upstream from each point on the streams of the Otter Creek watershed.

There is a major difference between this analysis and the last. Using the visual estimation technique, proportion of land usage upstream from any point was subjective. Using the surface area method it is actually precise. The electronic form of these maps contains retrievable information for every point on the map. Determining the proportion of a land use upstream from a point is as simple as pointing and clicking a mouse.

Cropland and pasture land usage (figure 5.2.3-2) have a major impact on the water quality of the Otter Creek watershed according to this method. Not only are almost all of the small tributary streams darkly colored, but the main channels of Otter Creek, Sulfur Creek, and North Branch Otter Creek are quite darkly colored as well.

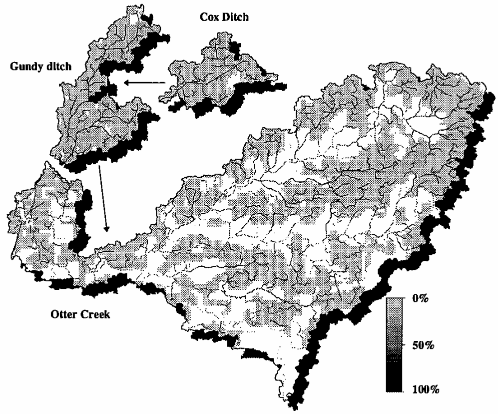

Figure 5.2.3-2. Percent cropland and pasture land uses upstream from each point on the streams of the Otter Creek watershed.

Forestland land usage (figure 5.2.3-3) has little impact on the water quality of the Otter Creek watershed according to this method. Not only are almost all of the tributary streams lightly colored, but also the main drainage-ways.

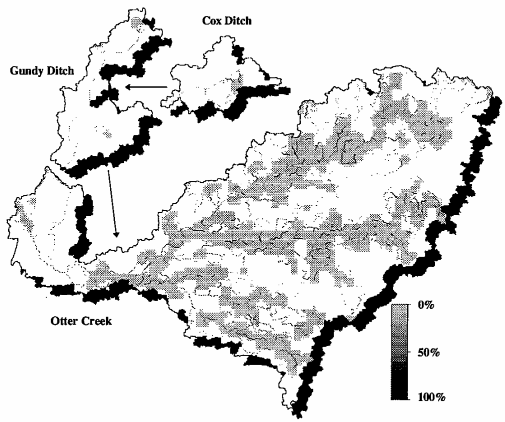

Figure 5.2.3-3. Percent forestland upstream from each point on the streams of the Otter Creek watershed.

Interpretation of figures 5.2.3-1, 2, and 3 seems to indicate that Cox and Gundy Ditch watersheds are the major contributors to any land use related water quality problems. These watersheds are composed almost entirely of land uses that would be likely to cause degradation of water resources. However, there are several problems with the surface area model and this interpretation of it.

With the second (visual estimation) method, which simply used maps and subjective judgments about the position of land uses relative to streams, it was possible to discern the reason for good water quality in Otter Creek. The surface area model, although appearing much more accurate due to its quantitative nature, is unable to account for positional effects. According to the surface area model, a cattle feedlot positioned in a watershed's upper reaches far from a sample site should have no more effect on at the sample site than a cattle feedlot located just upstream of the sample site on the stream channel. In Otter Creek, the surface area model does not account for the relative proximity of forests and streams.

Another common problem is interpretation. All of the analyses in this section have attempted to use land usage to infer water quality. An often made leap-in-logic is that areas with the worst water quality must cause the greatest water quality damage downstream. According to this thinking, Cox and Gundy Ditch watersheds probably have the worst water quality, therefore they must cause the most damage to Otter Creek. However, both Cox and Gundy Ditches combined contain less than one third of the cropland and pasture land usage that Otter Creek watershed (excluding the entire Gundy Ditch watershed) contains (table 5.2.1-1). This interpretation does not account for water volumes and dilution of land use impacts. The next section uses a "water volume method" to address both position and dilution problems.

5.2.4 Water Volume Model of Land Use Impact to Water Quality

Residential land use is uncommon in this watershed as shown in previous figures. Figure 5.2.4-1 depicts results of the hydrologic modeling method of land use impact assessment. These results do not greatly differ from the results based on watershed surface area in figure 5.2.3-1. In both cases, residential impacts to the main stream channels are small with only a few tributaries inside the residential areas showing potential for some intense, localized impacts.

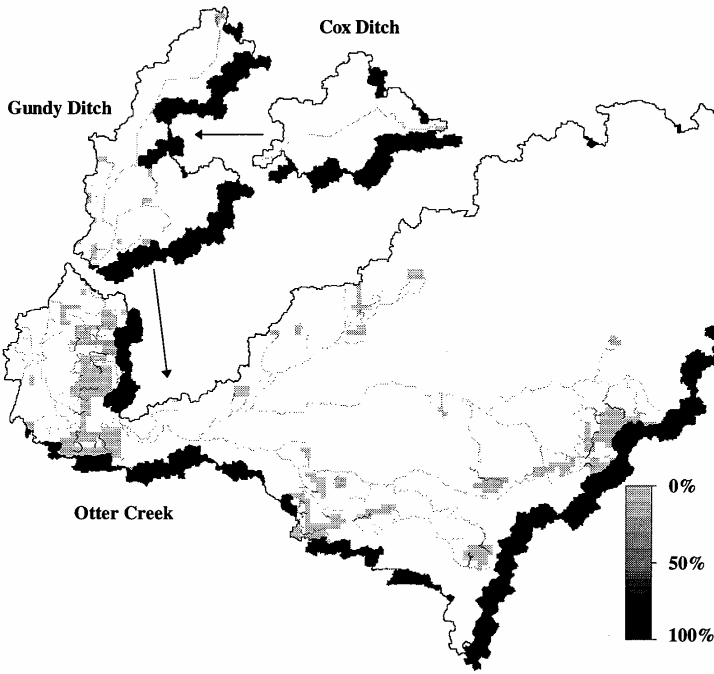

Figure 5.2.4-1. Percent residential land use impact to water quality upstream from each point on the streams of the Otter Creek watershed.

In Otter Creek watershed, it is the agricultural and forest lands that control the water quality of Otter Creek and its tributaries. In figure 5.2.4-2, potential water quality impacts from agricultural lands are depicted. This figure predicts radically different water quality in this watershed from that depicted in figure 5.2.3-2. Main stream channels are much lighter colored, indicating a smaller impact from agriculture in figure 5.2.4-2. Only small tributaries show potential for intense agricultural impacts. In contrast, predicted impacts from agriculture based upon surface area (figure 5.2.3-2) are much higher in the main stream channels. Impacts are high according to this model throughout the watershed.

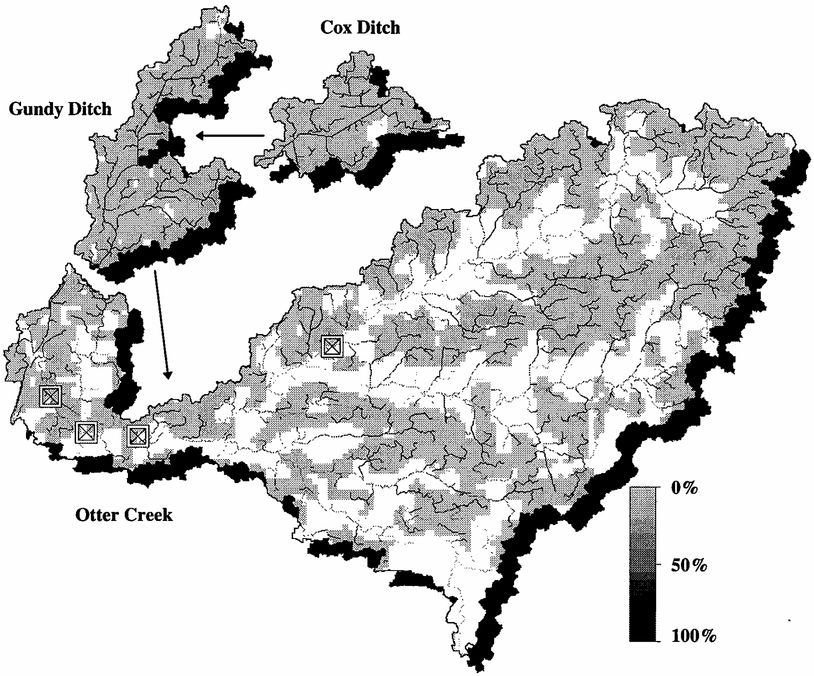

Figure 5.2.4-2. Percent cropland and pasture impact to water quality upstream from each point on the streams of the Otter Creek watershed (markers denote macroinvertebrate sample sites).

Figure 5.2.4-3 compares agricultural impacts to water quality calculated by the surface area and water volume methods at the four macroinvertebrate sample sites. Comparisons at these sites are made simply because the site characteristics cross a gradient from heavily wooded upstream riparian areas (furthest upstream, site M4) to a mixture of land uses in the upstream riparian zone (the furthest downstream, site M1). The surface area method does not respond to this gradient. This method considers agricultural impacts to be more-or-less constant at approximately 60% for all of the sites. The water volume method responds to the gradient. It predicts changes across this gradient from a 20% agricultural impact at the upstream (forested riparian zone) site to over a 40% impact at the downstream (mixed land use riparian zone) site.

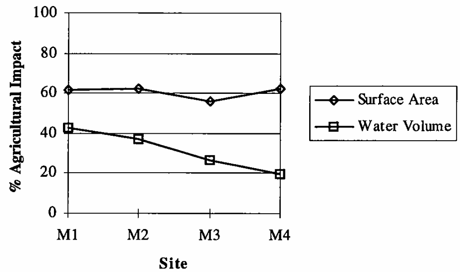

Figure 5.2.4-3. Comparison of land use impact calculation methods using cropland and pasture land use data. Lower is better.

In figure 5.2.4-4, potential water quality impacts from forestlands are depicted. Again, this figure predicts radically different water quality in this watershed from that depicted in figure 5.2.4-4. This time however, the main stream channels are much more darkly colored, indicating a much greater influence from forested lands (figure 5.2.4-4). Most small tributaries do not show up in this figure since few forestlands occur on the ridge tops.

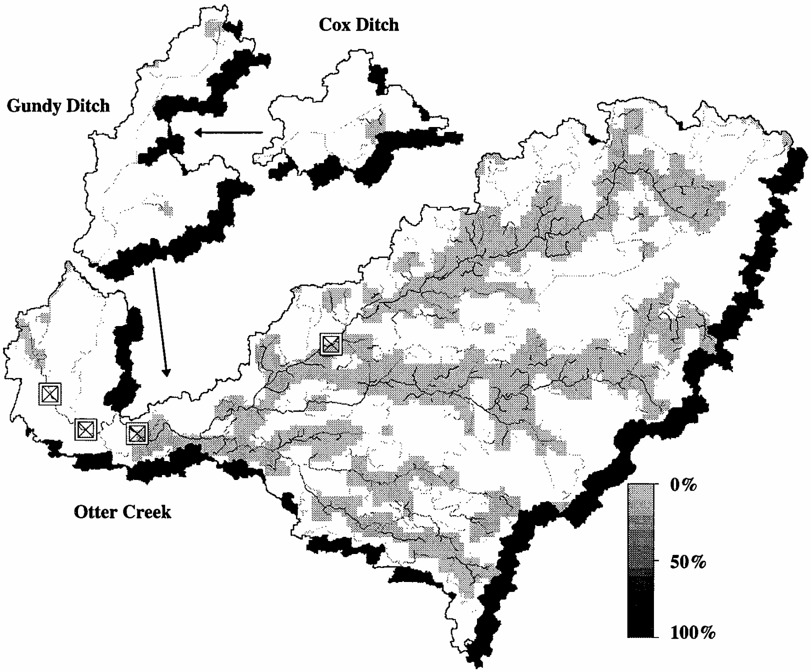

Figure 5.2.4-4. Percent forestland impact to water quality upstream from each point on the streams of the Otter Creek watershed (markers denote macroinvertebrate sample sites).

Notice that in both figure 5.2.4-3 and 5.2.4-5, forest and agricultural land uses switched dominance (majority water quality impact) at every macroinvertebrate site. Using the surface area method, agricultural land uses account for greater than 50% of the impact to water quality. Using the water volume method, forestland uses account for greater than 50% of the impact to water quality.

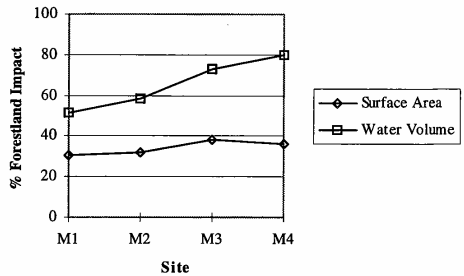

Figure 5.2.4-5. Comparison of land use impact calculation methods using forest land use data. Higher is better.

The implication is that the surface area model takes a very pessimistic view of water quality. The water volume method can (in some cases such as the Otter Creek watershed) present a much more optimistic view. Which model is right?

The 1991 macroinvertebrate data and Whitaker's (1976) fish survey seem to indicate that the water quality of Otter Creek is not dominated by agricultural impacts, but rather reflects the water quality of a watershed dominated by forestland influences. The biological data seems to support the water volume model. A more definitive answer will be provided by another on-going research project in which the author is involved. The calculated land use impacts at the four macroinvertebrate sample sites are listed in table 5.2.4-1.

Table 5.2.4-1. Comparison of land use impact calculation methods at macroinvertebrate sample sites.

	Macroinvertebrate Sample Sites			
Model	**M1**	**M2**	**M3**	**M4**
Residential				
% Surface Area	4.8	3.4	3.3	0.9
% Water Volume	5.1	4.4	0.2	0.1
Cropland and Pasture				
% Surface Area	61.6	61.9	55.9	62.3
% Water Volume	42.4	37.3	26.9	19.7
Forestland				
% Surface Area	30.7	32.2	38.0	36.1
% Water Volume	51.5	58.1	72.7	80.1
Other Land Uses				
% Surface Area	2.9	2.4	2.9	0.7
% Water Volume	1.0	0.2	0.3	0.1

% Surface area = % of watershed surface area occupied by a particular land use upstream from the site.
% Water Volume = % of water volume that passes through a particular land use upstream from the site.

It may seem that the water volume model is a simple change of scale and will always estimate higher forestland impacts and lower agricultural impacts. In reality though, the water volume method is a totally different measurement method and will produce lower estimates of forestland impacts than the surface area method in many watersheds. Forestland impacts are higher according to the water volume method in regions where forestlands are adjacent to streams and lower when other land uses are adjacent to streams. As a general rule (i.e., one that has many exceptions), forestlands border streams in geologically young regions such as the glaciated region of northern Indiana. In this region, river valleys are too narrow to support agriculture and urban areas. In northern Indiana agriculture and urban areas occupy the "highlands". On the other hand, in the non-glaciated (southern) parts of Indiana, forestlands occupy the highlands. Agriculture and urban areas occupy wide floodplain areas adjacent to river channels.

It is the author's opinion that the two models represent two extremes of the ability of land use to impact water quality. Some nonpoint source pollutants, such as agro-chemicals, probably cause impacts to water quality closer to the surface area model predictions. Since their application in a watershed is controlled by the surface area of the land uses that involve agro-chemicals and not by the amount water moving through an area. On the other hand erosion, substrate scour, and sedimentation cause impacts that are more closely approximated by the water volume model since these effects are related to the amount of water moving through an area.

5.2.5 Pretreatment Conditions: Part III

In many respects, the surface area and water volume models are habitat assessment methods. Similar to habitat assessment methods, the models aid in the prediction of water quality and biological integrity by controlling for differences in the physical characteristics of sample sites. These models have an advantage over USEPA and Ohio EPA habitat assessment methods since these models evaluate the entire watershed. These models also have disadvantages since they are based on 19 year old land use data. A disadvantage of USEPA and Ohio EPA habitat assessment methods is they evaluate only the watershed characteristics within the scorer's field of view. However, a major advantage of the USEPA and Ohio EPA methods is they can be repeated to assess change over time.

Regression models were constructed to evaluate the predictive ability of all four habitat assessment methods -- USEPA, Ohio EPA, surface area, and water volume. Twelve separate regression models were created to predict each of the three biotic metrics from each of the four habitat assessment methods. Biotic metrics were calculated for eleven macroinvertebrate samples in table 3.2-1. However, three of these samples were lab duplicates. Since lab duplicates are not independent observations of field conditions, they cannot be used for model testing as independent observations. However, they do represent useful information that can be used to improve the accuracy of the sample from which they were originally split. Therefore, lab duplicates and the sample from which they were split were averaged and substituted for the original value. After removal of the lab duplicates from the data set, the testing data set consisted of eight observations. Since a simple regression model consumes two degrees of freedom, only six were left for testing.

Since changes occurred in the Otter Creek watershed that will not be reflected in the 19 year old land use data, a predictive model based upon the land use data is more complex. In this model a class variable is added to the model to create a covariance model. The class variable accounts for changes due to powerline right-of-way maintenance. The inclusion of the extra parameter consumes another degree of freedom making it less likely that these models will be significant.

Results of the regression and covariance models are presented in Table 5.2.5-1. The EPT count was not significant in any of the models tested. Ohio and USEPA habitat assessment methods did not produce significant models with any of the biotic metrics. However, both the EPT/Chir and HBI biotic metric covariance models were significant at the α =.05 level.

Table 5.2.5-1. Comparison of habitat assessment methods.

	Habitat Assessment Method							
	USEPA		Ohio EPA		Surface Area		Water Volume	
Biotic Metric	R^2	P	R^2	P	R^2	P	R^2	P
EPT	0.052	0.596	0.106	0.432	0.293	0.420	0.271	0.454
EPT/Chir	0.247	0.210	0.352	0.121	0.820	0.0137	0.838	0.011
HBI	0.081	0.494	0.143	0.355	0.829	0.012	0.915	0.002

Shading indicates model is significant at P < .05 level.

The covariance models are composed of two variables -- a regression slope that accounts for variability in habitat and an offset that accounts for changes due to powerline right-of-way maintenance. The slope variable is most important for estimating pretreatment conditions for the LARE project. Table 5.2.5-2 contains the slope and offset significance measures (P).

Table 5.2.5-2. Comparison of land use assessment methods.

	Land Use Impact Assessment Method			
	Surface Area		Water Volume	
Biotic Metric	Slope (P)	Offset (P)	Slope (P)	Offset (P)
EPT/Chir	0.080	0.009	0.060	0.013
HBI	0.084	0.008	0.013	0.003

Shading indicates slope is significant at P < .05 level.

Although all four of the models are significant, table 5.2.5-2 indicates that most of the model significance is due to the offset. The surface area model is close to having a significant slope term. However, the water volume method was slightly better for both metrics. As stated previously, it is the author's opinion that the two models represent the extremes of the ability of land usage to impact water quality and biological integrity. The actual impact of land usage is probably somewhere in between. However, it is the author's opinion and the statistics corroborate this, that the water volume method is a more accurate method overall.

The covariance model is depicted in figure 5.2.5-1. The bottom line indicates conditions in Otter Creek prior to powerline maintenance (1991), as well as, pretreatment conditions the LARE project should be evaluated against. (Recall that lower is better for HBI Scores.) The top line is the impacted conditions measured in 1994. The two lines are parallel meaning the slope parameter is the same for both lines. The offset is the vertical distance between the two lines. According to the covariance analysis, powerline right-of-way maintenance increased HBI scores (lower is better for HBI scores) by 0.6 HBI units in Otter Creek's impacted area. The impacted area probably extends from the furthest upstream powerline crossings on Otter and Sulfur Creeks to Otter Creek's confluence with the Wabash River.

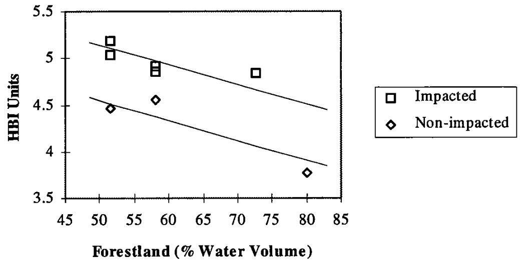

Figure 5.2.5-1. Covariance analysis relating HBI scores to the water volume model ($R^2 = 0.92$, $P = .002$).

5.2.6 Potential to Damage Water Quality

The previous analyses (surface area and water volume models) depicted water quality impacts to each site on a stream due to all of the land uses upstream from that site. The following analysis is the converse of the previous analysis. The next analysis predicts the potential of each site in a watershed to damage the entire watershed's water quality.

Figure 5.2.6-1 is the most important piece of information in this report. It depicts sites with the most potential to damage water quality in the Otter Creek watershed. The dark areas have the highest damage potential. If the dark areas are protected with wide riparian zones (50 - 100 m) of woody vegetation, the water quality will be high. Encroachment of damaging land uses into these areas will greatly diminish water quality and biological integrity.

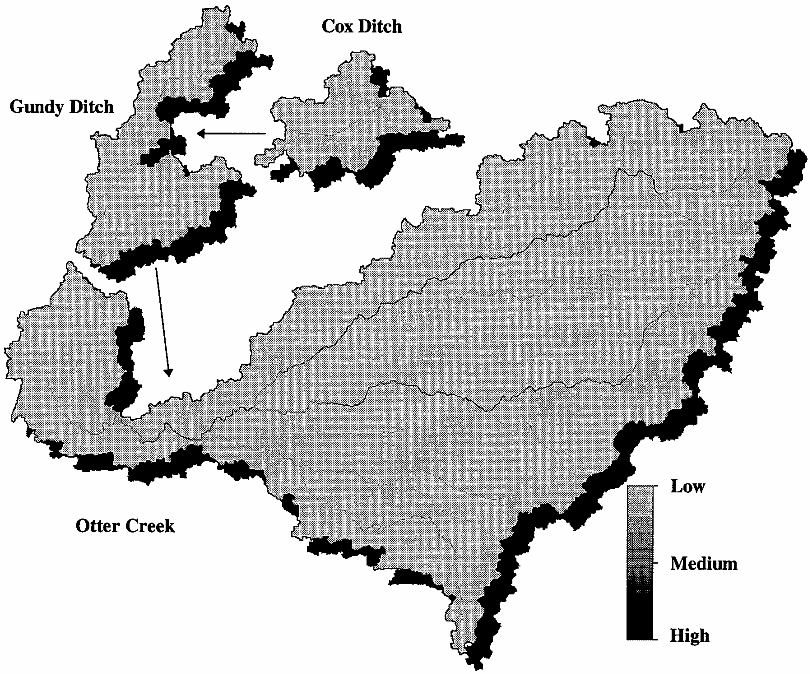

Figure 5.2.6-1. Sites within the Otter Creek watershed that have a high potential to degrade water quality due to their position alone.

Notice that Cox Ditch has very little potential to damage the Otter Creek watershed's water quality. Most of the high damage potential lands occur along the stream channels. It is the author's understanding that the LARE project is away from the Cox Ditch channel. Even if this project was on Cox Ditch's channel, there are probably other parcels of land with more potential to damage water quality that should be treated first. These other lands would yield a higher return for the LARE program's investment.

In figure 5.2.6-2, very little of the high damage potential lands occur on the residential or agricultural lands. However it must be recognized that the land use data used in this map, as well as all of the other maps preceding it, have a very coarse resolution and are 16 years old. The actual distribution of land uses may have changed somewhat or may vary at a finer resolution (in plots smaller than 200 m × 200 m). It was apparent from driving through the watershed, that much of Otter Creek has a thin vegetated riparian zone that would not show up at a 200 m × 200 m resolution.

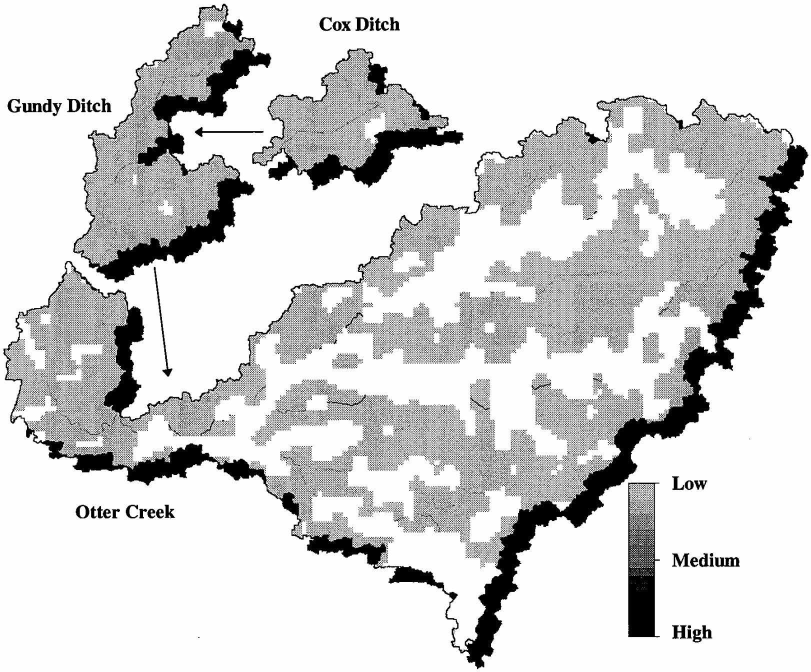

Figure 5.2.6-2. Sites within the Otter Creek watershed that have a high potential to degrade water quality due to their position and land usage (USGS (1979) land use categories "residential" and "cropland and pasture").

In any event, the previous figure (5.2.6-1) is not based on land use data and represents a relatively accurate depiction of the damage potential of all lands in the Otter creek watershed. Land use practices that may cause degradation of water quality on these sensitive lands can be identified more accurately than is depicted in figure 5.2.6-2 by walking the streams of interest, or less labor-intensively, by looking at recent aerial photographs.

The previous damage potential analysis is based on the water volume model. The same analysis could be run using the surface area model. According to this model, sites that pose the greatest threat to water quality are located at the furthest points upstream (i.e., on the watershed divides). The reason for this is that these sites have the longest drainage paths and therefore, can cause damage at the most points downstream. According to the surface area model, the least damaging sites would be located on the stream channel near the watershed outlet since these sites damage the least number of points downstream. Obviously, sighting a cattle feedlot or some other water quality degrading land use on a stream channel will damage water quality more than sighting the same facility near the watershed divide where only a small volume of water will drain through it. This problem with the surface area model is the major reason for discouraging this models use. This problem is caused by the inability of the surface area model to account for land use position.

6. SUMMARY

6.1 Objective #1 Summary

The first objective was to review existing sources of information that are pertinent to the water quality and biological integrity of the Otter Creek watershed. The historical fisheries data indicates the fish community of the Otter Creek watershed was quite diverse. IDEM fish tissue chemistry data is disturbing from the standpoint that the number pesticide detections is high. However, this is not uncommon in agricultural regions. The levels are considered safe by IDEM, ISDH, and IDNR. IDEM sediment chemistry data seems to indicate sediment contamination is not a problem. Incidental observations of fish tends to indicate that fish populations are still healthy and diverse. It is doubtful that the fish community has changed much from the time of Whitaker's (1976) study. Incidental observations of freshwater mussels indicate that several freshwater mussel species do occur in the Otter Creek watershed. Additionally, IDEM's 1991 macroinvertebrate and habitat assessment surveys indicated Otter Creek's water and habitat quality can be some of the best in the state. Taken together, the evidence indicates that Otter Creek is an extremely valuable natural resource.

6.2 Objective #2 Summary

The objective of sections two and three was to establish a biological monitoring and habitat assessment pretreatment (baseline) data set from which the success of the proposed LARE project can be evaluated. Although, the powerline maintenance project made this a very difficult chore, it does appear that the LARE project can be evaluated from the 1991 IDEM data set for estimates of pretreatment conditions. The combined LHR, IDEM, and post-treatment data sets should be used in a covaiance model to produce variability estimates. The water volume method results should be used as the covariate.

6.3 Objective #3 Summary

The third objective was to evaluate the LARE project's potential for success (from the standpoint of biological improvement) and make recommendations for project improvements. This objective was accomplished by examining the damage potential of sites within the Otter Creek watershed. This technique indicates sites within the Cox Ditch watershed have little potential to seriously damage the Otter Creek watershed's water quality. Additionally, the damage potential analysis indicates the LARE project could have a much more significant impact if it could be implemented at other locations in the watershed (figure 5.2.6-1).

7. CONCLUSIONS

The Otter Creek watershed suffers from several problems. All of these problems can and should be remediated. The identified problems were:

1. power line right-of-way maintenance;
2. encroachment of non-forested land uses into the riparian zones;
3. channelization for drainage improvement purposes; and
4. pesticide contamination of fishes.

All of these problems would heal over with time if energy and resources were not actually expended to cause the problems. The solution to all of these problems is to maintain a riparian buffer zone of woody vegetation around the watershed's streams and ditches. Powerline crossings can be accomodated using shorter vegetation or selectively killing vegetation as it becomes too tall. Encroachment of non-forested land uses into riparian zones can be addressed through zoning laws or purchases of development rights. Drainage improvements would probably not be necessary as often if ditches were protected by wider riparian zones of woody vegetation. Wider riparian zones of woody vegetation will also help to filter out pestcides and other agricultural chemicals before they reach waterways. However, the real problem with Otter Creek is the lack of political and economic incentives to solve the problems afflicting this watershed.

The Otter Creek watershed has some exceptional qualities. Some of indications of these exceptional qualities are:

1. The 1991 biomonitoring results indicate that this stream is one of the best streams in the state;
2. Whitaker's (1976) 12-year fish population survey at the Old Mill Dam site indicates that Otter Creek may have one of the most diverse fish populations for a stream of its size in the state; and
3. The incidental observations of freshwater mussels indicate this important and rapidly disappearing group is present and may have representives of several species in this watershed.

These exceptional qualities are largely unknown to the people who inhabit the watershed. Making these qualities known would help create some political and economic incentives. Once people appreciate the resource and understand how to protect it, the political incentives have been created.

In a perfect world, the political incentives would create the economic incentives to maintain riparian zones. People would want to protect Otter Creek because it would be the "right thing to do". However, the real world is more complex. The benefits and costs of water quality and its protection and enhancement are spatially seperated. In order to facilitate the maintenance and restoration of Otter Creek's water quality and biological integrity, governmental intervention is probably necessary. It is probably necessary for government (state, county, or local consevancy district) to purchase the development rights on riparian lands from landowners and importantly, to ensure that those development right agreements are being observed.

It is the author's opinion that the currently proposed LARE project will not result in observable improvements in the Otter Creek watershed. This is not only due to other problems in this watershed or even the actions of the Vigo County Drainage Board on Cox Ditch, but is inherent to the project itself. In order for the project to be successful it needs to impove a large volume of water. Since the project area is located in the very upper reaches of the watershed, it effects only a small volume of water. By the time the water impacted by this project reaches an area of permanent water where benefits to water quality and biological integrity can actually occur, the treatment effects will be negligible due to dilution with the tremendous volume of untreated water from untreated portions of the watershed.

8. RECOMMENDATIONS

These recommendations have been arranged according to increasing level of public commitment to improving the Otter Creek watershed's water quality and biological integrity. The first set assume a low level of commitment in terms of public resources. The second assume more, etc. At some point prior to the end of the list of recommendations, the public's resources and commitment will probably run out. The recommendations beyond that point might be considered for possible implementation at some future time. In any event, the recommendations are presented in an order that the author deems logical (i.e. the first set of recommendations should be implemented prior to the initiation of sets of recommendations further down this list).

8.1 Low Public Commitment Recommendation

The author recommends:

1. the Cox Ditch (LARE) project be re-evaluated. It is the author's opinion that this project will not produce measureable benefits to the Otter Creek watershed's water quality and biological integrity.

8.2 Moderate Public Commitment Recommendations

The author recommends:

1. river enhancement projects be coordinated with county drainage boards. It is conceivable that a well designed river enhancement project could fulfill the goals of both IDNR and the county drainage boards. By combining the funds of both parties, joint projects might enhance water quality, biological integrity, and reduce channel maintenance costs while maintaining the ditch's desired drainage characteristics.
2. measures be taken to mitigate the effects of tree clearing under utility lines. The author's suggestions are detailed in section 4.3.1. This would seem to be an excellent LARE project and/or NPS pollution control project funded by USEPA through IDEM. Potentially, the LARE program's contribution could be the required local matching funds.
3. the number of monitoring sites should be increased. The positioning of the monitoring sites should take advantage of the water quality predictions in figure 5.2.4-4. These monitoring sites should be positioned across a range of predicted water quality.
4. IDNR provide information about Otter Creek aquatic fauna to landowners in and around the Otter Creek watershed. As explained in section 2.3.5, land owners would likely take better care of Otter Creek if they understood its value and especially if they could capitalize on Otter Creek's value. In that section, the idea of producing a brochure for the people who live near Otter Creek was alluded to. The brochure would tell local land owners about the

diversity of Otter Creek and explain why they should value it. Much of the information in the brochure could come from this report and the expanded monitoring program, especially if this monitoring includes other organism groups of interest to local landowners (e.g., fish, mussels, and possibly mammals, birds, etc.).

Another function of the brochures could be to educate landowners about what they could do to protect and enhance Otter Creek. A section explaining the value of riparian vegetation showing pictures of both good and bad riparian zones would go a long way toward protecting water quality and biological integrity.

8.3 High Public Commitment Recommendations

If state government, county government, local conservation group, or some combination of these entities considered Otter Creek to be extremely valuable to water quality and biological integrity, the following recommendations would apply.

The author recommends:

1. conservation easements be purchased adjacent to stream channel's and converted to forestland. Figure 10.2.2-1 should be used to guide land purchases. Selling prices should be compared to the particular parcel's damage potential. Lands should be purchased that prevent the most damage at the lowest price.
2. the number of monitoring sites should be increased. Larger public expenditures require thorough monitoring in order to ensure that actual benefits of expenditures are being realized. Position of monitoring sites should be based on figure 5.2.6-1's water quality predictions. Monitoring sites should be placed at points where water quality and biological integrity are expected to be improved. The predicted and realized benefits should be compared. As Otter Creek's water quality improves, the law of diminishing returns predicts that at some point public funds would be better spent on other projects.
3. the monitoring data be included in updated informational brochures. The brochures will act as reminders of Otter Creek's value to local landowners.

9. ACKNOWLEDGMENTS

This study was funded by a Lake and River Enhancement Grant from the Indiana Department of Natural Resources through the Vigo County Soil and Water Conservation District. The author would like to thank Jim Ray, Barbara Curry, Gwen White and Robert Wise of IDNR for their invaluable assistance. Brant Fisher was extremely helpful in field work. Norm Levine and Darryl McCauley of Purdue University were extremely helpful (and patient) with the author's GIS questions and data requests. The author is especially indebted to all members of the IDEM, OWM, Biological Studies Section who have spent years collecting and identifying macroinvertebrate samples, as well as, organizing IDEM's data into a useful electronic format.

The staff of the Lake and River Enhancement Program are to be commended for their desire to objectively assess the results of their work. For so many government programs, the measure of success is the number of dollars spent or effort expended rather than progress toward the original goal for which the program was designed. Typically, an objective evaluation is unwelcome. The fact that the LARE program personnel seek out these assessments indicates they are serious about achieving the program's goals.

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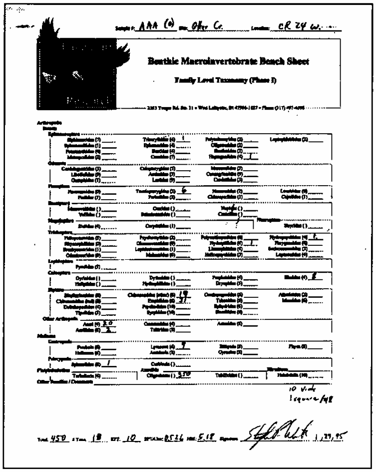
APPENDICES

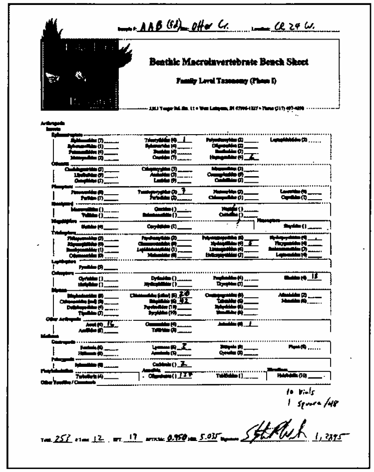
Appendix A. Macroinvertebrate Identification Laboratory Notes



Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

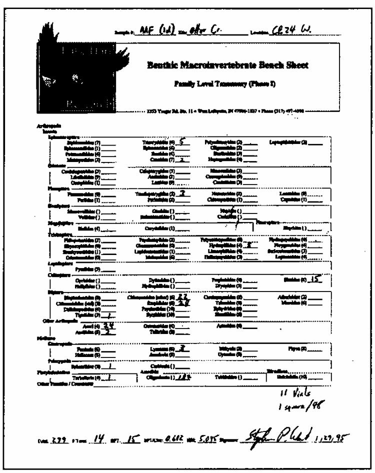
Site M1 (1994): Macroinvertebrate Identification Bench Sheet (original sample)



Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

Site M1 (1994): Macroinvertebrate Identification Bench Sheet (field duplicate)



Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

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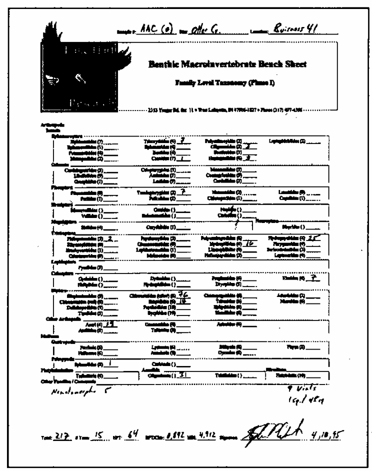
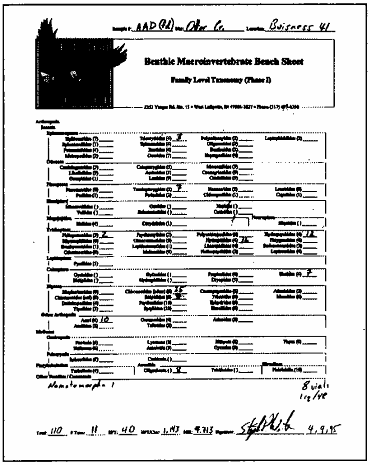


Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

Site M2 (1994): Macroinvertebrate Identification Bench Sheet (original sample)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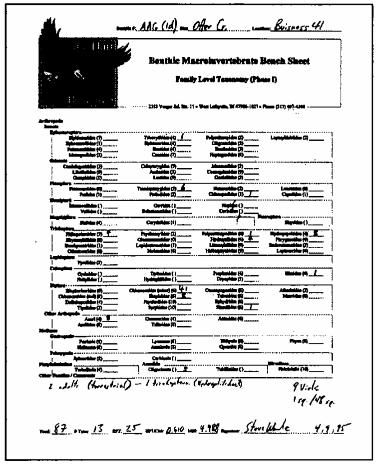
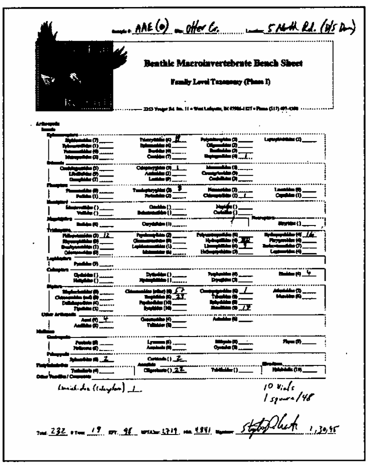
Family Level Taxonomy (Phase I)

Site M2 (1994): Macroinvertebrate Identification Bench Sheet (field duplicate)

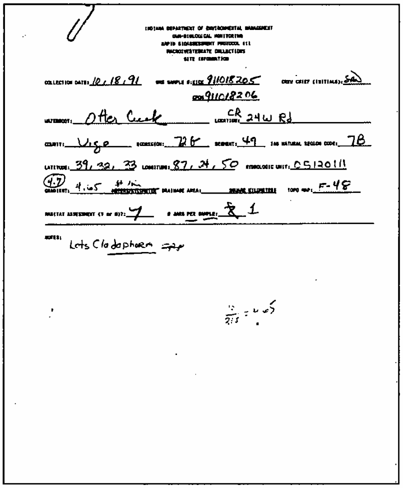

Benthic Macroinvertebrate Bench Sheet
Family Level Taxonomy (Phase I)

Site M2 (1994): Macroinvertebrate Identification Bench Sheet (laboratory duplicate of field duplicate)

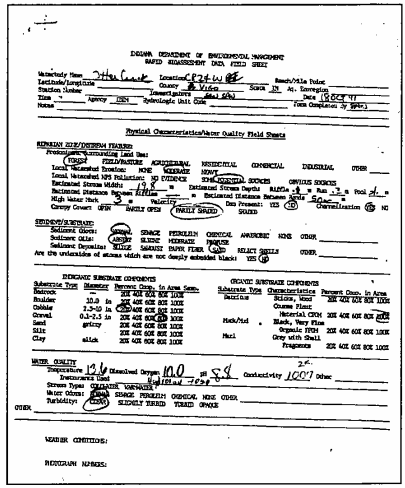

Benthic Macroinvertebrate Bench Sheet
Family Level Taxonomy (Phase I)

Site M3 (1994): Macroinvertebrate Identification Bench Sheet (original sample)

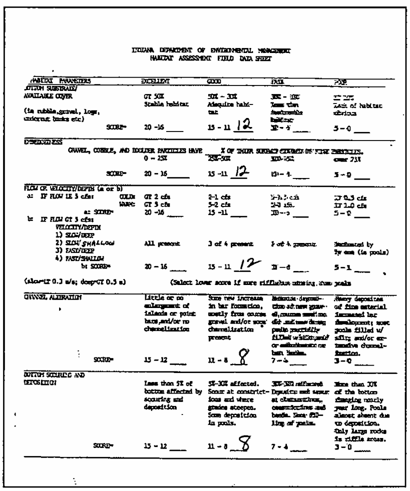
Appendix B. Habitat Assessment Forms



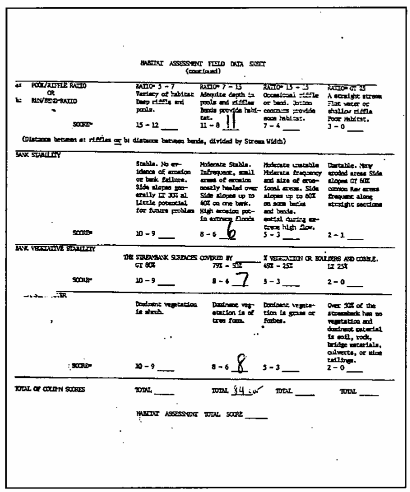
Site M1 (1991): Macroinvertebrate Sample Tracking Form



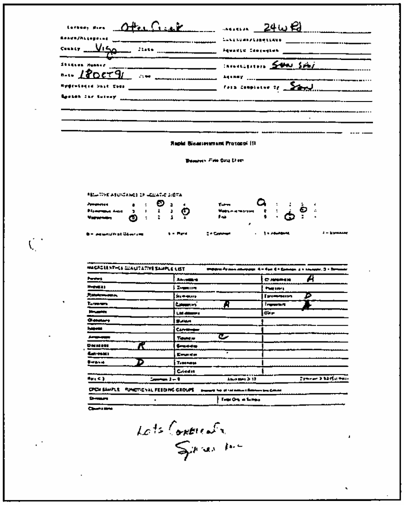
Site M1 (1991): Physical Characteristics/ Water Quality Field Data Sheet



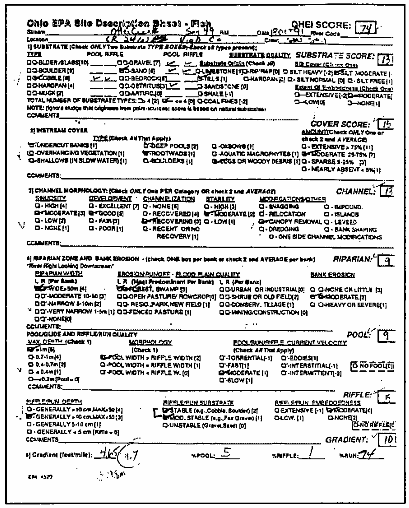
Site M1 (1991): USEPA Habitat Assessment Form



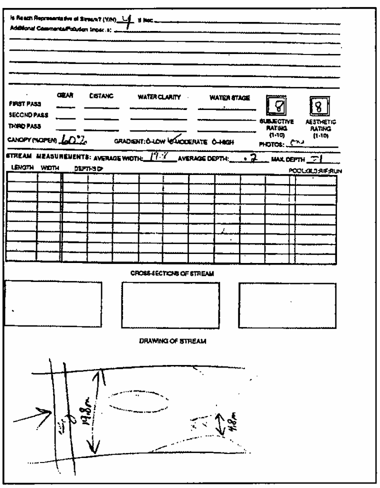
Site M1 (1991): USEPA Habitat Assessment Form (continued)



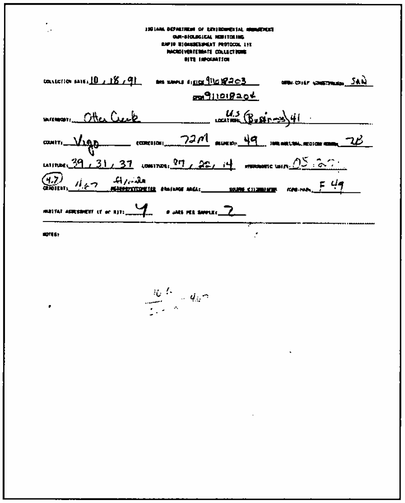
Site M1 (1991): Biosurvey Field Data Sheet



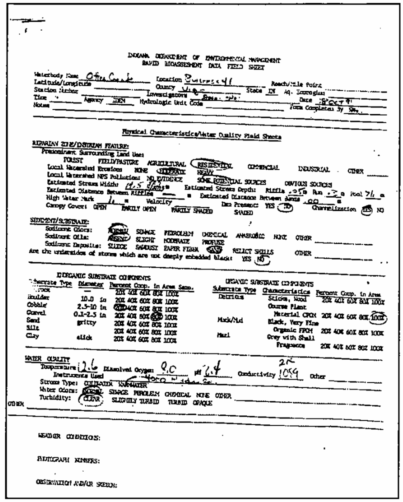
Site M1 (1991): Ohio EPA Habitat Assessment Form



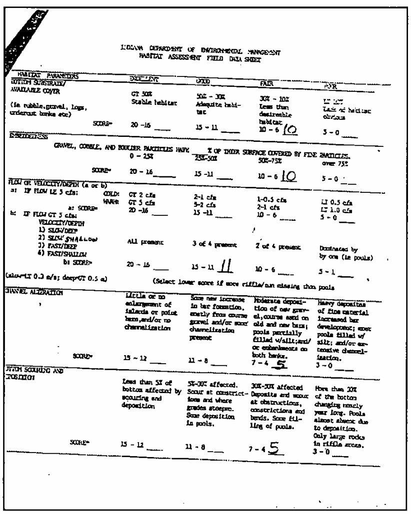
Site M1 (1991): Ohio EPA Habitat Assessment Form (continued)



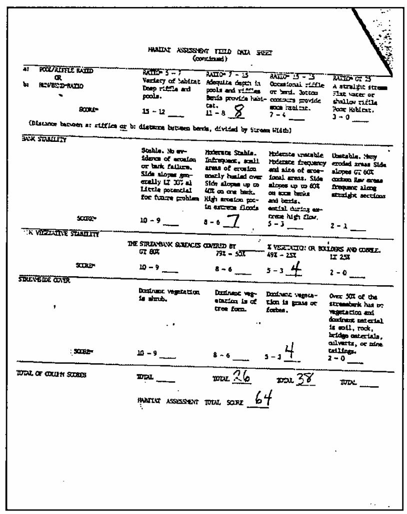
Site M2 (1991): Macroinvertebrate Sample Tracking Form



Site M2 (1991): Physical Characteristics/ Water Quality Field Data Sheet



Site M2 (1991): USEPA Habitat Assessment Form



Site M2 (1991): USEPA Habitat Assessment Form (continued)

Ohio EPA Site Description Sheet - Fish

OHEI SCORE: 67

Stream ____ RM ____ Date ____ River Code ____

Location ____ Crew ____

1] SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Check all types present);

SUBSTRATE SCORE:

TOTAL NUMBER OF SUBSTRATE TYPES:

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)

COMMENTS

2] INSTREAM COVER

COVER SCORE:

COMMENTS:

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

CHANNEL:

COMMENTS:

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank)

"River Right Looking Downstream"

RIPARIAN:

COMMENTS:

POOL/GLIDE AND RIFFLE/RUN QUALITY

POOL:

COMMENTS:

RIFFLE:

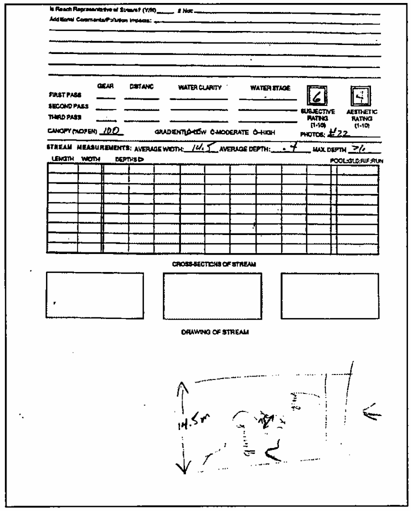
COMMENTS

GRADIENT:

6] Gradient (feet/mile): 4.67 (4.7) %POOL: 5 %RIFFLE: 1 %RUN: 94

EPA 4520

Site M2 (1991): Ohio EPA Habitat Assessment Form



Is Reach Representative of Stream? (Y/N) ____ If Not: ____

Additional Comments/Pollution Impacts: ____

	GEAR	DISTANC	WATER CLARITY	WATER STAGE
FIRST PASS				
SECOND PASS				
THIRD PASS				

SUBJECTIVE RATING (1-10): 6

AESTHETIC RATING (1-10): 4

CANOPY (%OPEN) 100 GRADIENT: O-LOW O-MODERATE O-HIGH PHOTOS: #22

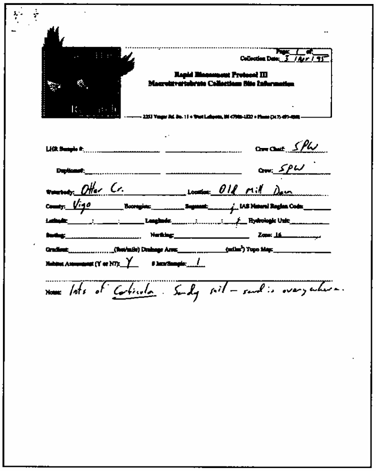
STREAM MEASUREMENTS: AVERAGE WIDTH: 14.5 AVERAGE DEPTH: .4 MAX DEPTH >1

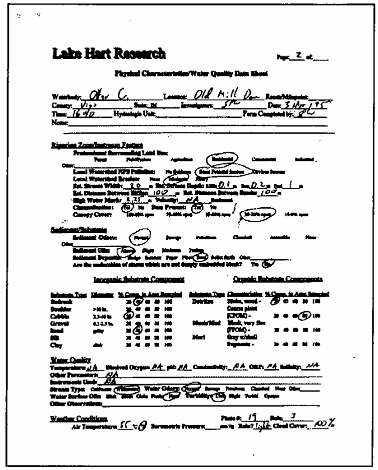
CROSS-SECTIONS OF STREAM

DRAWING OF STREAM

14.5 m

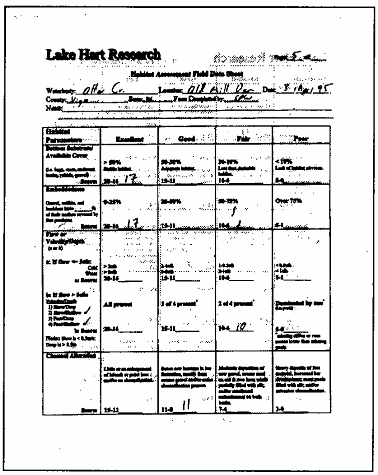
Site M2 (1991): Ohio EPA Habitat Assessment Form (continued)

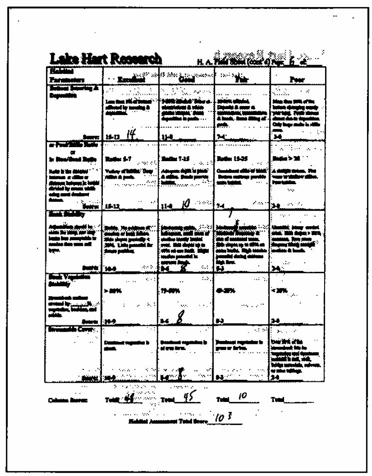




Site M3 (1994): Macroinvertebrate Sample Tracking Form

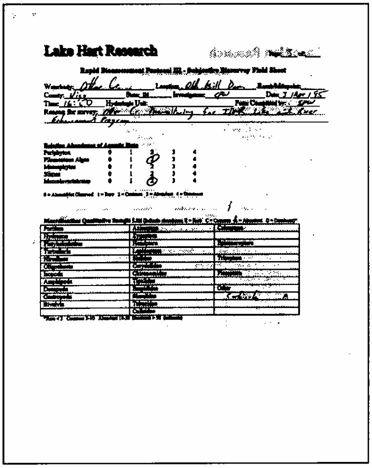
Site M3 (1994): Physical Characteristics/ Water Quality Field Data Sheet





Site M3 (1994): USEPA Habitat Assessment Form

Site M3 (1994): USEPA Habitat Assessment Form (continued)



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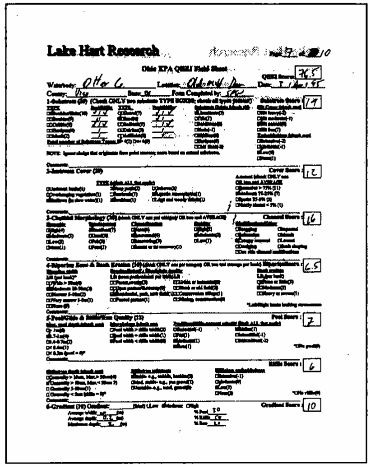
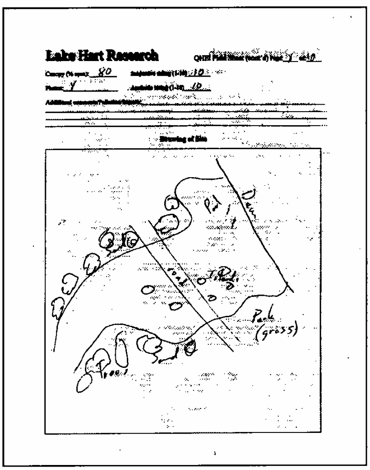
Site M3 (1994): Biosurvey Field Data Sheet



Lake Hart Research

Site M3 (1994): Ohio EPA Habitat Assessment Form



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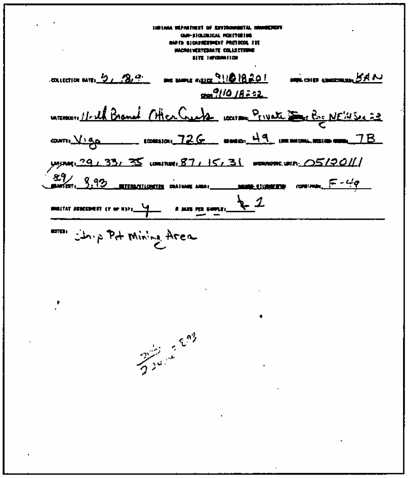
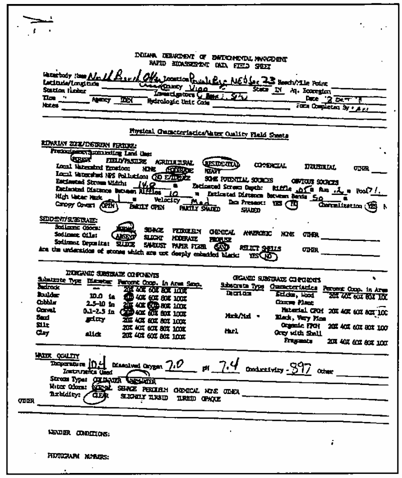
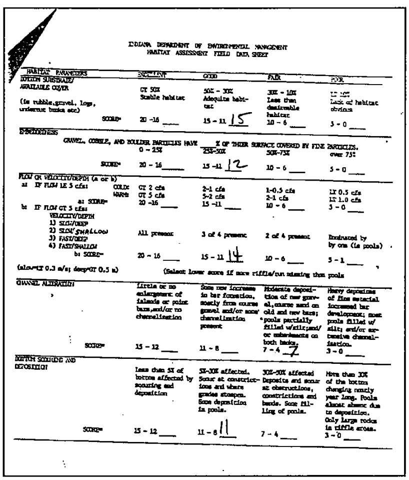
Site M3 (1994): Ohio EPA Habitat Assessment Form (continued)



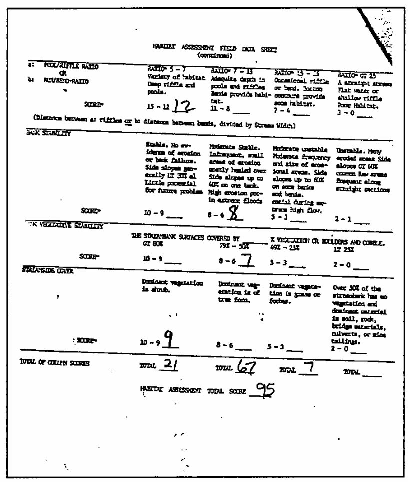
Site M4 (1991): Macroinvertebrate Sample Tracking Form



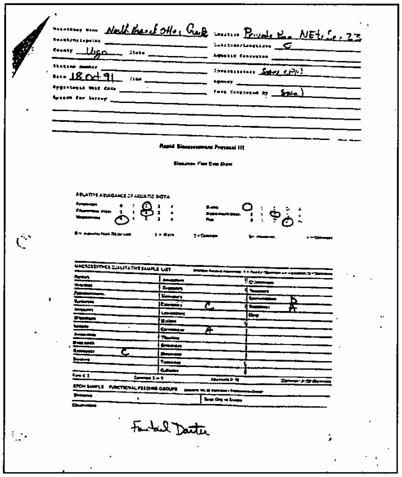
Site M4 (1991): Physical Characteristics/ Water Quality Field Data Sheet

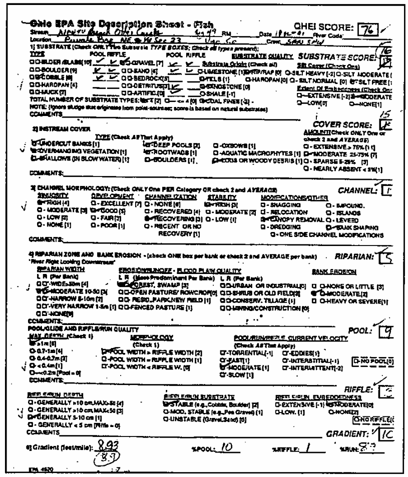


Site M4 (1991): USEPA Habitat Assessment Form



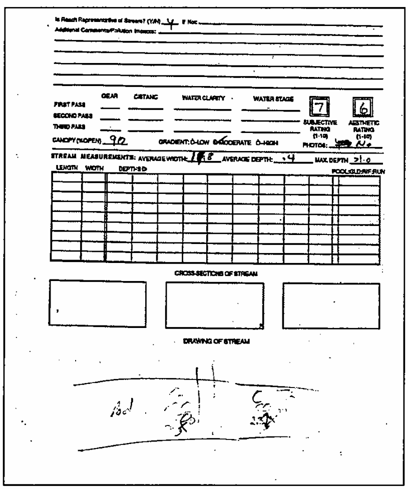
Site M4 (1991): USEPA Habitat Assessment Form (continued)





Site M4 (1991): Biosurvey Field Data Sheet

Site M4 (1991): Ohio EPA Habitat Assessment Form



Site M4 (1991): Ohio EPA Habitat Assessment Form (continued)

Appendix C. Fish Tissue Chemistry Analysis (Complete Results)

Appendix Table C10-1. Comparison of IDEM heavy metal fish tissue chemisty results from 1984 (shaded) and 1991.

	IDEM Sediment Chemistry Results (ppb)					
ElementName	**049-84**	**050-84**	**20300984**	**20300985**	**20300986**	**20301006**
Arsenic	54.00	52.00	N.A.	N.A.	N.A.	N.A.
Cadmium	< 20.00	30.00	< 10.00	< 10.00	20.00	< 10.00
Chromium	760.00	260.00	N.A.	N.A.	N.A.	N.A.
Copper	350.00	410.00	N.A.	N.A.	N.A.	N.A.
Lead	< 90.00	< 90.00	10.00	60.00	60.00	29.00
Mercury	79.00	120.00	130.00	160.00	70.00	130.00
Zinc	16,700.00	19,800.00	N.A.	N.A.	N.A.	N.A.

N.A. = Not analyzed.

Numbers preceded by “<” indicate that the actual value is below the instrument detection limits. The number following the “<” is the detection limit.

Appendix Table C20-2. Comparison of IDEM pesticide and PCB fish tissue chemisty results from 1984 (shaded) and 1991.

	IDEM Fish Tissue Chemistry Results (ppb)				
Chemical Name	**049-84**	**050-84**	**20300984**	**20300985**	**20300986**
Alpha BHC	1.000	< 1.000	< 8.000	< 8.000	< 8.000
Beta BHC	N.A.	< 1.000	< 8.000	< 8.000	< 8.000
Delta BHC	N.A.	< 1.000	< 8.000	< 8.000	< 8.000
Gamma BHC	< 1.000	< 1.000	< 8.000	< 8.000	< 8.000
Heptachlor	N.A.	N.A.	< 8.000	< 8.000	< 8.000
Aldrin	N.A.	N.A.	< 8.000	< 8.000	< 8.000
Heptachlor Epoxide	21.000	10.000	< 8.000	< 8.000	< 8.000
Dieldrin	18.000	8.000	< 10.000	15.000	< 10.000
4,4'-DDE	60.000	12.000	< 10.000	52.000	< 10.000
Endrin	N.A.	N.A.	< 10.000	< 10.000	< 10.000
4,4'-DDD	10.000	2.000	< 10.000	< 10.000	< 10.000
Endosulfan Sulfate	N.A.	N.A.	< 20.000	< 20.000	< 20.000
4,4'-DDT	40.000	7.000	< 20.000	< 20.000	< 20.000
Methoxychlor	N.A.	N.A.	< 20.000	< 20.000	< 20.000
Gamma (trans) Chlordane	10.000	4.000	< 8.000	< 8.000	< 8.000
Alpha (cis) Chlordane	23.000	9.000	< 8.000	< 8.000	< 8.000
Hexachlorobenzene	1.000	1.000	< 10.000	< 10.000	< 10.000
1,4'-DDE	N.A.	N.A.	< 20.000	13.000	< 20.000
1,4'-DDD	N.A.	N.A.	< 10.000	< 10.000	< 10.000
1,4'-DDT	N.A.	N.A.	< 20.000	< 20.000	< 20.000
Pentachloroanisole	1.000	< 1.000	< 16.000	< 16.000	< 16.000
Oxychlordane	11.000	6.000	< 8.000	10.000	< 8.000
trans-Nonachlor	53.000	17.000	< 16.000	53.000	9.100
cis-Nonachlor	10.000	4.000	< 8.000	18.000	< 8.000
Total PCBs	200.000	248.000	132.000	229.000	70.000

Endosulfan I	N.A.	N.A.	< 20.000	< 20.000	< 20.000
Endosulfan II	N.A.	N.A.	< 20.000	< 20.000	< 20.000
Toxaphene	N.A.	N.A.	< 10.000	< 10.000	< 10.000
Endrin Ketone	N.A.	N.A.	< 10.000	< 10.000	< 10.000
Endrin Aldehyde	N.A.	N.A.	< 10.000	< 10.000	< 10.000
% Lipids	5.82 - 7.58	2.90 - 3.97	2.07	3.99	3.07

Numbers preceded by "<" indicate that the actual value is below the instrument detection limits. The number following the "<" is the detection limit.

N.A. = Not analyzed.

Appendix D. Sediment Chemistry Analysis (Complete Results)

Appendix Table D10-3. Comparison of IDEM heavy metal sediment chemisty results from 1984 (shaded) and 1992 with estimated background concentrations.

Element Name	Estimated Background (ppb)[a]	IDEM Sediment Chemistry Results (ppb)			
		D1827-84	D1828-84	20700412	20700422
Aluminum (Al)	21,100,000	N.A.	N.A.	5,370,000	6,190,000
Antimony (Sb)	3,229.33	200	200	< 5600	< 5200
Arsenic (As)	17,600	3400	4600	4500	4500
Barium (Ba)	190,000	N.A.	N.A.	51,100	51,400
Beryllium (Be)	1,041.27	< 1600	< 2900	410	380
Cadmium (Cd)	7,088.63	< 1600	< 2900	< 660	< 620
Calcium (Ca)	116,000,000	N.A.	N.A.	8,790,000	9,350,000
Chromium (Cr)	71,000	< 3300	17,000	7700	8700
Cobalt (Co)	24,017.95	N.A.	N.A.	7500	7300
Copper (Cu)	77,000	4300	16,000	8200	8700
Iron (Fe)	37,000,000	N.A.	N.A.	13,600,000	13,800,000
Lead (Pb)	114,000	12,000	19,000	9100	10,000
Magnesium (Mg)	20,000,000	N.A.	N.A.	2,130,000	2,360,000
Manganese (Mn)	1,440,000	N.A.	N.A.	895,000	918,000
Mercury (Hg)	237	20	110	30	30
Nickel (Ni)	63,000	12,000	15,000	15,400	14,900
Potassium (K)	2,300,000	N.A.	N.A.	570,000	710,000
Selenium (Se)	1,637.89	100	270	N.A.	N.A.
Silver (Ag)	2,776.25	< 700	< 1500	< 990	< 930
Sodium (Na)	470,556.35	N.A.	N.A.	117,000	129,000
Thallium (Tl)	2,248.02	< 7000	< 15,000	N.A.	N.A.
Vanadium (V)	46,000	N.A.	N.A.	14,300	16,000
Zinc (Zn)	310,000	55,000	76,000	53,900	54,300

[a] Background estimates taken from Wente (1994) appendix table A1 for non-spatially variable background estimates. Spatially variable background estimates were taken from table C1 and 2 using Vigo County estimates.

N.A. = Not analyzed.

Numbers preceded by "<" indicate that the actual value is below the instrument detection limits. The number following the "<" is the detection limit.

Appendix Table D20-4. Comparison of IDEM pesticide and PCB sediment chemisty results from 1984 (shaded) and 1992 with estimated background concentrations.

Chemical Name	Estimated Background (ppb)[a]	IDEM Sediment Chemistry Results (ppb)			
		D1827-84	D1828-84	20700412	20700422
Alpha BHC	2.8918	< 1.000	< 1.000	< 8.600	< 8.700
Beta BHC	8.0736	< 3.000	< 3.000	< 8.600	< 8.700
Delta BHC	0.001	< 2.000	< 2.000	< 8.600	< 8.700
Gamma BHC	0.0683	< 0.200	< 0.200	< 1.700	< 1.700
Heptachlor	2.3846	< 2.000	< 2.000	< 8.600	< 8.700
Aldrin	0.4081	< 2.000	< 2.000	< 13.800	< 14.000
Heptachlor Epoxide	0.6069	< 2.000	< 2.000	< 8.600	< 8.700
Dieldrin	10.6652	< 1.000	< 1.000	< 1.700	< 1.700

4,4'-DDE	6.0958	< 2.000	< 2.000	< 3.400	< 3.500
Endrin	7.0602	< 8.000	< 8.000	< 17.000	< 17.000
4,4'-DDD	7.4911	< 2.000	< 2.000	< 3.400	< 3.500
Endosulfan Sulfate	1.538	< 20.000	< 20.000	< 17.000	< 17.000
4,4'-DDT	2.6865	< 2.000	< 2.000	< 3.400	< 3.500
Methoxychlor	4.1792	< 20.000	< 20.000	< 17.000	< 17.000
Gamma (trans) Chlordane	5.2454	N.A.	N.A.	< 1.700	< 1.700
Alpha (cis) Chlordane	3.736	N.A.	N.A.	< 1.700	< 1.700
Hexachlorobenzene	5.5666	N.A.	N.A.	< 8.600	< 8.700
1,4'-DDE	0.5597	N.A.	N.A.	< 3.400	< 3.500
1,4'-DDD	24.6326	N.A.	N.A.	< 3.400	< 3.500
1,4'-DDT	0.5249	N.A.	N.A.	< 3.400	< 3.500
Pentachloroanisole	1.3317	N.A.	N.A.	< 34.000	< 35.000
Oxychlordane	0.1577	N.A.	N.A.	< 1.700	< 1.700
trans-Nonachlor	2.4972	N.A.	N.A.	< 1.700	< 1.700
cis-Nonachlor	0.9277	N.A.	N.A.	< 1.700	< 1.700
Arochlor 1221	9.659	< 50.000	< 50.000	< 86.000	< 87.000
Arochlor 1232	9.659	< 50.000	< 50.000	< 86.000	< 87.000
Arochlor 1016	10.5603	< 10.000	< 10.000	< 86.000	< 87.000
Arochlor 1242	40.5374	< 10.000	< 10.000	< 86.000	< 87.000
Arochlor 1248	297.8131	< 10.000	< 10.000	< 86.000	< 87.000
Arochlor 1254	129.0418	18.000	45.000	< 86.000	< 87.000
Arochlor 1260	6.9236	< 10.000	< 20.000	< 86.000	< 87.000
Endosulfan I	2.6472	< 4.000	< 4.000	< 17.000	< 17.000
Endosulfan II	6.6081	< 10.000	< 10.000	< 17.000	< 17.000
Toxaphene	13.3866	< 200.000	< 200.000	< 34.000	< 35.000
Arochlor 1262	14.8923	N.A.	N.A.	N.A.	N.A.
Total Chlordane	8.4289	< 10.000	< 20.000	N.A.	N.A.
Endrin Ketone	5.7809	N.A.	N.A.	< 8.600	< 8.700
Endrin Aldehyde	0.605	N.A.	N.A.	< 8.600	< 8.700

[a] Background estimates taken from Wente (1994) appendix table A2.

Numbers preceded by "<" indicate that the actual value is below the instrument detection limits. The number following the "<" is the detection limit.

N.A. = Not analyzed.

Sample #: AAA (0) Site: Otter Cr. Location: CR 24 W.

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda

Insecta

Ephemeroptera

Siphlonuridae (7)	Tricorythidae (4) 1	Polymitarcyidae (2)	Leptophlebiidae (2)
Ephemerellidae (1)	Ephemeridae (4)	Oligonuridae (2)	
Potamanthidae (4)	Baetidae (4)	Baetiscidae (3)	
Metropodidae (2)	Caenidae (7)	Heptageniidae (4) 1	

Odonata

Cordulegastridae (3)	Calopterygidae (5)	Macromiidae (3)
Libellulidae (9)	Aeshnidae (3)	Coenagrionidae (9)
Gomphidae (1)	Lestidae (9)	Corduliidae (3)

Plecoptera

Pteronarcidae (0)	Taeniopterygidae (2) 6	Nemouridae (2)	Leuctridae (0)
Perlidae (1)	Perlodidae (2)	Chloroperlidae (1)	Capniidae (1)

Hemiptera

Macroveliidae ( )	Gerridae ( )	Nepidae ( )
Veliidae ( )	Belastomatidae ( )	Corixidae ( )

Megaloptera

Sialidae (4)	Corydalidae (1)

Neuroptera

Sisyridae ( )

Trichoptera

Philopotamidae (3)	Psychomyiidae (2)	Polycentropodidae (6)	Hydropsychidae (4) 1
Rhyacophilidae (0)	Glossosomatidae (0)	Hydroptilidae (4) 1	Phryganeidae (4)
Brachycentridae (1)	Lepidostomatidae (1)	Limnephilidae (4)	Sericostomatidae (3)
Odontoceridae (0)	Molannidae (6)	Helicopsychidae (3)	Leptoceridae (4)

Lepidoptera

Pyralidae (5)

Coleoptera

Gyrinidae ( )	Dytiscidae ( )	Psephenidae (4)	Elmidae (4) 8
Haliplidae ( )	Hydrophilidae ( )	Dryopidae (5)	

Diptera

Blephariceridae (0)	Chironomidae (other) (6) 19	Ceratopagonidae (6)	Athericidae (2)
Chironomidae (red) (8)	Empididae (6) 31	Tabanidae (6)	Muscidae (6)
Dolichopodidae (4)	Psychodidae (10)	Ephydridae (6)	
Tipulidae (3)	Syrphidae (10)	Simuliidae (6)	

Other Arthopoda

Acari (4) 20	Gammaridae (4)	Astacidae (6)
Asellidae (8) 2	Talitridae (8)	

Mollusca

Gastropoda

Ferrissia (6)	Lymnaea (6) 9	Bithynia (8)	Physa (8)
Helisoma (6)	Amnicola (8)	Gyraulus (8)	

Pelecypoda

Sphaeriidae (8) 1	Corbicula ( )

Platyhelminthes

Turbellaria (4)

Annelida

Oligochaeta ( ) 350	Tubificidae ( )

Hirudinea

Helobdella (10)

Other Families / Comments

10 vials
1 square /48

Total: 450 # Taxa: 13 EPT: 10 EPT/Chir: 0.526 HBI: 5.18 Signature: [signature] 1/29/95

Sample #: AAB (fd) Site: Otter Cr. Location: CR 24 W.

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda

Insecta

Ephemeroptera

Siphlonuridae (7) ______	Tricorythidae (4) 1	Polymitarcyidae (2) ______	Leptophlebiidae (2) ______
Ephemerellidae (1) ______	Ephemeridae (4) ______	Oligoneuridae (2) ______	
Potamanthidae (4) ______	Baetidae (4) ______	Baetiscidae (3) ______	
Metropodidae (2) ______	Caenidae (7) ______	Heptageniidae (4) 6	

Odonata

Cordulegastridae (3) ______	Calopterygidae (5) ______	Macromiidae (3) ______
Libellulidae (9) ______	Aeshnidae (3) ______	Coenagrionidae (9) ______
Gomphidae (1) ______	Lestidae (9) ______	Corduliidae (3) ______

Plecoptera

Pteronarcidae (0) ______	Taeniopterygidae (2) 7	Nemouridae (2) ______	Leuctridae (0) ______
Perlidae (1) ______	Perlodidae (2) ______	Chloroperlidae (1) ______	Capniidae (1) ______

Hemiptera

Macroveliidae ( ) ______	Gerridae ( ) ______	Nepidae ( ) ______
Veliidae ( ) ______	Belastomatidae ( ) ______	Corixidae ( ) ______

Megaloptera

Sialidae (4) ______	Corydalidae (1) ______

Neuroptera

Sisyridae ( ) ______

Trichoptera

Philopotamidae (3) ______	Psychomyiidae (2) ______	Polycentropodidae (6) ______	Hydropsychidae (4) ______
Rhyacophilidae (0) ______	Glossosomatidae (0) ______	Hydroptilidae (4) 5	Phryganeidae (4) ______
Brachycentridae (1) ______	Lepidostomatidae (1) ______	Limnephilidae (4) ______	Sericostomatidae (3) ______
Odontoceridae (0) ______	Molannidae (6) ______	Helicopsychidae (3) ______	Leptoceridae (4) ______

Lepidoptera

Pyralidae (5) ______

Coleoptera

Gyrinidae ( ) ______	Dytiscidae ( ) ______	Psephenidae (4) ______	Elmidae (4) 13
Haliplidae ( ) ______	Hydrophilidae ( ) ______	Dryopidae (5) ______	

Diptera

Blephariceridae (0) ______	Chironomidae (other) (6) 20	Ceratopagonidae (6) ______	Athericidae (2) ______
Chironomidae (red) (8) ______	Empididae (6) 42	Tabanidae (6) ______	Muscidae (6) ______
Dolichopodidae (4) ______	Psychodidae (10) ______	Ephydridae (6) ______	
Tipulidae (3) ______	Syrphidae (10) ______	Simuliidae (6) ______	

Other Arthopoda

Acari (4) 16	Gammaridae (4) ______	Astacidae (6) 1
Asellidae (8) ______	Talitridae (8) ______	

Mollusca

Gastropoda

Ferrissia (6) ______	Lymnaea (6) 3	Bithynia (8) ______	Physa (8) ______
Helisoma (6) ______	Amnicola (8) ______	Gyraulus (8) ______	

Pecelypoda

Sphaeriidae (8) ______	Corbicula ( ) 2

Platyhelminthes

Turbellaria (4) ______

Annelida

Oligochaeta ( ) 137 Tubificidae ( ) ______

Hirudinea

Helobdella (10) ______

Other Families / Comments

10 Vials
1 square /48

Total: 253 # Taxa: 12 EPT: 19 EPT/Chir: 0.950 HBI: 5.035 Signature: [signature] 1/27/95

Sample #: AAF (1d) Site: Otter Cr. Location: CR 24 W.

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda

Insecta

Ephemeroptera

Siphlonuridae (7)		Tricorythidae (4)	5	Polymitarcyidae (2)		Leptophlebiidae (2)	
Ephemerellidae (1)		Ephemeridae (4)		Oligonuridae (2)			
Potamanthidae (4)		Baetidae (4)		Baetiscidae (3)			
Metropodidae (2)		Caenidae (7)	2	Heptageniidae (4)			

Odonata

Cordulegastridae (3)		Calopterygidae (5)		Macromiidae (3)	
Libellulidae (9)		Aeshnidae (3)		Coenagrionidae (9)	
Gomphidae (1)		Lestidae (9)		Corduliidae (3)	

Plecoptera

Pteronarcidae (0)		Taeniopterygidae (2)	3	Nemouridae (2)		Leuctridae (0)	
Perlidae (1)		Perlodidae (2)		Chloroperlidae (1)		Capniidae (1)	

Hemiptera

Macroveliidae ( )		Gerridae ( )		Nepidae ( )	
Veliidae ( )		Belastomatidae ( )		Corixidae ( )	

Megaloptera

Sialidae (4)		Corydalidae (1)	

Neuroptera

Sisyridae ( )	

Trichoptera

Philopotamidae (3)		Psychomyiidae (2)		Polycentropodidae (6)		Hydropsychidae (4)	
Rhyacophilidae (0)		Glossosomatidae (0)		Hydroptilidae (4)	5	Phryganeidae (4)	
Brachycentridae (1)		Lepidostomatidae (1)		Limnephilidae (4)		Sericostomatidae (3)	
Odontoceridae (0)		Molannidae (6)		Helicopsychidae (3)		Leptoceridae (4)	

Lepidoptera

Pyralidae (5)	

Coleoptera

Gyrinidae ( )		Dytiscidae ( )		Psephenidae (4)		Elmidae (4)	15
Haliplidae ( )		Hydrophilidae ( )		Dryopidae (5)			

Diptera

Blephariceridae (0)		Chironomidae (other) (6)	22	Ceratopagonidae (6)		Athericidae (2)	
Chironomidae (red) (8)		Empididae (6)	28	Tabanidae (6)		Muscidae (6)	
Dolichopodidae (4)		Psychodidae (10)		Ephydridae (6)			
Tipulidae (3)	1	Syrphidae (10)		Simuliidae (6)			

Other Arthopoda

Acari (4)	24	Gammaridae (4)		Astacidae (6)	
Asellidae (8)	2	Talitridae (8)			

Mollusca

Gastropoda

Ferrissia (6)		Lymnaea (6)	3	Bithynia (8)		Physa (8)	
Helisoma (6)		Amnicola (8)		Gyraulus (8)			

Pelecypoda

Sphaeriidae (8)	1	Corbicula ( )	

Platyhelminthes

Turbellaria (4)	1

Annelida

Oligochaeta ( )	187	Tubificidae ( )	

Hirudinea

Helobdella (10)	

Other Families / Comments

11 Vials

1 square/48

Total: 299 # Taxa: 14 EPT: 15 EPT/Chir: 0.682 HBI: 5.045 Signature: [illegible] 1/29/95

Sample #: AAC (0) Site: Otter Cr. Location: Buisness 41

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda

Insecta

Ephemeroptera

Siphlonuridae (7)	Tricorythidae (4) 7	Polymitarcyidae (2)	Leptophlebiidae (2)
Ephemerellidae (1)	Ephemeridae (4)	Oligonuridae (2) 3	
Potamanthidae (4)	Baetidae (4)	Baetiscidae (3)	
Metropodidae (2)	Caenidae (7) 1	Heptageniidae (4) 3	

Odonata

Cordulegastridae (3)	Calopterygidae (5)	Macromiidae (3)
Libellulidae (9)	Aeshnidae (3)	Coenagrionidae (9)
Gomphidae (1)	Lestidae (9)	Corduliidae (3)

Plecoptera

Pteronarcidae (0)	Taeniopterygidae (2) 7	Nemouridae (2)	Leuctridae (0)
Perlidae (1)	Perlodidae (2)	Chloroperlidae (1)	Capniidae (1)

Hemiptera

Macroveliidae ( )	Gerridae ( )	Nepidae ( )
Veliidae ( )	Belastomatidae ( )	Corixidae ( )

Megaloptera

Sialidae (4)	Corydalidae (1)

Neuroptera

Sisyridae ( )

Trichoptera

Philopotamidae (3) 2	Psychomyiidae (2)	Polycentropodidae (6)	Hydropsychidae (4) 25
Rhyacophilidae (0)	Glossosomatidae (0)	Hydroptilidae (4) 16	Phryganeidae (4)
Brachycentridae (1)	Lepidostomatidae (1)	Limnephilidae (4)	Sericostomatidae (3)
Odontoceridae (0)	Molannidae (6)	Helicopsychidae (3)	Leptoceridae (4)

Lepidoptera

Pyralidae (5)

Coleoptera

Gyrinidae ( )	Dytiscidae ( )	Psephenidae (4)	Elmidae (4) 7
Haliplidae ( )	Hydrophilidae ( )	Dryopidae (5)	

Diptera

Blephariceridae (0)	Chironomidae (other) (6) 76	Ceratopagonidae (6)	Athericidae (2)
Chironomidae (red) (8)	Empididae (6) 14	Tabanidae (6)	Muscidae (6)
Dolichopodidae (4)	Psychodidae (10)	Ephydridae (6)	
Tipulidae (3)	Syrphidae (10)	Simuliidae (6)	

Other Arthopoda

Acari (4) 19	Gammaridae (4)	Astacidae (6)
Asellidae (8)	Talitridae (8)	

Mollusca

Gastropoda

Ferrissia (6)	Lymnaea (6)	Bithynia (8)	Physa (8)
Helisoma (6)	Amnicola (8)	Gyraulus (8)	

Pecelypoda

Sphaeriidae (8) 1	Corbicula ( )

Platyhelminthes

Turbellaria (4)

Annelida

Oligochaeta ( ) 31

Tubificidae ( )

Hirudinea

Helobdella (10)

Other Families / Comments

Nematomorpha 5

9 Vials

1sq. / 48sq.

Total: 217 # Taxa: 15 EPT: 64 EPT/Chir: 0.842 HBI: 4.912 Signature: [signature] 4,10,95

Sample #: AAD (fd) Site: Otter Cr. Location: Buisness 41

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda

Insecta

Ephemeroptera

Siphlonuridae (7) ______	Tricorythidae (4) 3	Polymitarcyidae (2) ______	Leptophlebiidae (2) ______
Ephemerellidae (1) ______	Ephemeridae (4) ______	Oligonuridae (2) ______	
Potamanthidae (4) ______	Baetidae (4) ______	Baetiscidae (3) ______	
Metropodidae (2) ______	Caenidae (7) ______	Heptageniidae (4) ______	

Odonata

Cordulegastridae (3) ______	Calopterygidae (5) ______	Macromiidae (3) ______
Libellulidae (9) ______	Aeshnidae (3) ______	Coenagrionidae (9) ______
Gomphidae (1) ______	Lestidae (9) ______	Corduliidae (3) ______

Plecoptera

Pteronarcidae (0) ______	Taeniopterygidae (2) 7	Nemouridae (2) ______	Leuctridae (0) ______
Perlidae (1) ______	Perlodidae (2) ______	Chloroperlidae (1) ______	Capniidae (1) ______

Hemiptera

Macroveliidae ( ) ______	Gerridae ( ) ______	Nepidae ( ) ______
Veliidae ( ) ______	Belastomatidae ( ) ______	Corixidae ( ) ______

Megaloptera

Sialidae (4) ______	Corydalidae (1) ______

Neuroptera

Sisyridae ( ) ______

Trichoptera

Philopotamidae (3) 2	Psychomyiidae (2) ______	Polycentropodidae (6) ______	Hydropsychidae (4) 12
Rhyacophilidae (0) ______	Glossosomatidae (0) ______	Hydroptilidae (4) 16	Phryganeidae (4) ______
Brachycentridae (1) ______	Lepidostomatidae (1) ______	Limnephilidae (4) ______	Sericostomatidae (3) ______
Odontoceridae (0) ______	Molannidae (6) ______	Helicopsychidae (3) ______	Leptoceridae (4) ______

Lepidoptera

Pyralidae (5) ______

Coleoptera

Gyrinidae ( ) ______	Dytiscidae ( ) ______	Psephenidae (4) ______	Elmidae (4) 7
Haliplidae ( ) ______	Hydrophilidae ( ) ______	Dryopidae (5) ______	

Diptera

Blephariceridae (0) ______	Chironomidae (other) (6) 35	Ceratopagonidae (6) ______	Athericidae (2) ______
Chironomidae (red) (8) ______	Empididae (6) 9	Tabanidae (6) ______	Muscidae (6) ______
Dolichopodidae (4) ______	Psychodidae (10) ______	Ephydridae (6) ______	
Tipulidae (3) ______	Syrphidae (10) ______	Simuliidae (6) ______	

Other Arthopoda

Acari (4) 10	Gammaridae (4) ______	Astacidae (6) ______
Asellidae (8) ______	Talitridae (8) ______	

Mollusca

Gastropoda

Ferrissia (6) ______	Lymnaea (6) ______	Bithynia (8) ______	Physa (8) ______
Helisoma (6) ______	Amnicola (8) ______	Gyraulus (8) ______	

Pelecypoda

Sphaeriidae (8) ______	Corbicula ( ) ______

Platyhelminthes

Turbellaria (4) ______

Annelida

Oligochaeta ( ) 8 Tubificidae ( ) ______

Hirudinea

Helobdella (10) ______

Other Families / Comments

Nematomorpha 1

8 vials
1 sq/48

Total: 110 # Taxa: 11 EPT: 40 EPT/Chir: 1.143 HBI: 4.713 Signature: [signature] 4/9/95

Sample #: AAG (1d) Site: Otter Cr. Location: Buisness 41

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda
Insecta

Ephemeroptera

Siphlonuridae (7) ___	Tricorythidae (4) 1	Polymitarcyidae (2) ___	Leptophlebiidae (2) ___
Ephemerellidae (1) ___	Ephemeridae (4) ___	Oligonuridae (2) ___	
Potamanthidae (4) ___	Baetidae (4) ___	Baetiscidae (3) ___	
Metropodidae (2) ___	Caenidae (7) ___	Heptageniidae (4) ___	

Odonata

Cordulegastridae (3) ___	Calopterygidae (5) ___	Macromiidae (3) ___
Libellulidae (9) ___	Aeshnidae (3) ___	Coenagrionidae (9) ___
Gomphidae (1) ___	Lestidae (9) ___	Corduliidae (3) ___

Plecoptera

Pteronarcidae (0) ___	Taeniopterygidae (2) 6	Nemouridae (2) ___	Leuctridae (0) ___
Perlidae (1) ___	Perlodidae (2) ___	Chloroperlidae (1) 1	Capniidae (1) ___

Hemiptera

Macroveliidae ( ) ___	Gerridae ( ) ___	Nepidae ( ) ___
Veliidae ( ) ___	Belastomatidae ( ) ___	Corixidae ( ) ___

Megaloptera

Sialidae (4) ___	Corydalidae (1) ___

Neuroptera

Sisyridae ( ) ___

Trichoptera

Philopotamidae (3) 4	Psychomyiidae (2) ___	Polycentropodidae (6) 1	Hydropsychidae (4) 8
Rhyacophilidae (0) ___	Glossosomatidae (0) ___	Hydroptilidae (4) 4	Phryganeidae (4) ___
Brachycentridae (1) ___	Lepidostomatidae (1) ___	Limnephilidae (4) ___	Sericostomatidae (3) ___
Odontoceridae (0) ___	Molannidae (6) ___	Helicopsychidae (3) ___	Leptoceridae (4) ___

Lepidoptera

Pyralidae (5) ___

Coleoptera

Gyrinidae ( ) ___	Dytiscidae ( ) ___	Psephenidae (4) ___	Elmidae (4) 1
Haliplidae ( ) ___	Hydrophilidae ( ) ___	Dryopidae (5) ___	

Diptera

Blephariceridae (0) ___	Chironomidae (other) (6) 41	Ceratopagonidae (6) ___	Athericidae (2) ___
Chironomidae (red) (8) ___	Empididae (6) 8	Tabanidae (6) ___	Muscidae (6) ___
Dolichopodidae (4) ___	Psychodidae (10) ___	Ephydridae (6) ___	
Tipulidae (3) ___	Syrphidae (10) ___	Simuliidae (6) 1	

Other Arthopoda

Acari (4) 8	Gammaridae (4) ___	Astacidae (6) ___
Asellidae (8) ___	Talitridae (8) ___	

Mollusca

Gastropoda

Ferrissia (6) ___	Lymnaea (6) ___	Bithynia (8) ___	Physa (8) ___
Helisoma (6) ___	Amnicola (8) ___	Gyraulus (8) ___	

Pelecypoda

Sphaeriidae (8) ___	Corbicula ( ) ___

Platyhelminthes

Turbellaria (4) ___

Annelida

Oligochaeta ( ) 3 Tubificidae ( ) ___

Hirudinea

Helobdella (10) ___

Other Families / Comments

2 adults (terrestrial) — 1 trichoptera (Hydroptilidae?)

9 Vials
1 sq. / 48 sq.

Total: 87 # Taxa: 13 EPT: 25 EPT/Chir: 0.610 HBI: 4.988 Signature: Steve White 4/9/95

Sample #: AAE (0) Site: Otter Cr. Location: 5 North Rd. (D/S D...

Lake Hart Research

Benthic Macroinvertebrate Bench Sheet

Family Level Taxonomy (Phase I)

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

Arthropoda

Insecta

Ephemeroptera

Siphlonuridae (7)	Tricorythidae (4) 19	Polymitarcyidae (2)	Leptophlebiidae (2)
Ephemerellidae (1)	Ephemeridae (4)	Oligoneuridae (2)	
Potamanthidae (4)	Baetidae (4)	Baetiscidae (3)	
Metropodidae (2)	Caenidae (7)	Heptageniidae (4) 1	

Odonata

Cordulegastridae (3)	Calopterygidae (5) 1	Macromiidae (3)
Libellulidae (9)	Aeshnidae (3)	Coenagrionidae (9)
Gomphidae (1)	Lestidae (9)	Corduliidae (3)

Plecoptera

Pteronarcidae (0)	Taeniopterygidae (2) 8	Nemouridae (2)	Leuctridae (0)
Perlidae (1)	Perlodidae (2)	Chloroperlidae (1) 1	Capniidae (1)

Hemiptera

Macroveliidae ( )	Gerridae ( )	Nepidae ( )
Veliidae ( )	Belastomatidae ( )	Corixidae ( )

Megaloptera

Sialidae (4)	Corydalidae (1)

Neuroptera

Sisyridae ( )

Trichoptera

Philopotamidae (3) 12	Psychomyiidae (2)	Polycentropodidae (6)	Hydropsychidae (4) 16
Rhyacophilidae (0)	Glossosomatidae (0)	Hydroptilidae (4) 32	Phryganeidae (4)
Brachycentridae (1)	Lepidostomatidae (1)	Limnephilidae (4) 9	Sericostomatidae (3)
Odontoceridae (0)	Molannidae (6)	Helicopsychidae (3)	Leptoceridae (4)

Lepidoptera

Pyralidae (5)

Coleoptera

Gyrinidae ( )	Dytiscidae ( )	Psephenidae (4)	Elmidae (4) 4
Haliplidae ( )	Hydrophilidae ( )	Dryopidae (5)	

Diptera

Blephariceridae (0)	Chironomidae (other) (6) 57	Ceratopagonidae (6) 1	Athericidae (2)
Chironomidae (red) (8)	Empididae (6) 23	Tabanidae (6)	Muscidae (6)
Dolichopodidae (4)	Psychodidae (10)	Ephydridae (6)	
Tipulidae (3)	Syrphidae (10)	Simuliidae (6) 17	

Other Arthopoda

Acari (4) 4	Gammaridae (4)	Astacidae (6)
Asellidae (8)	Talitridae (8)	

Mollusca

Gastropoda

Ferrissia (6)	Lymnaea (6)	Bithynia (8)	Physa (8)
Helisoma (6)	Amnicola (8)	Gyraulus (8)	

Pecelypoda

Sphaeriidae (8) 2	Corbicula ( ) 2

Platyhelminthes

Turbellaria (4)

Annelida

Oligochaeta ( ) 22 Tubificidae ( )

Hirudinea

Helobdella (10)

Other Families / Comments

Limnichidae (Coleoptera) 1

10 Vials
1 square/48

Total: 232 # Taxa: 19 EPT: 98 EPT/Chir: 1.719 HBI: 4.841 Signature: [signature] 1/30/95

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL MONITORING
RAPID BIOASSESSMENT PROTOCOL III
MACROIVERTEBRATE COLLECTIONS
SITE INFORMATION

COLLECTION DATE: 10 / 18 / 91 BMS SAMPLE #: KICK 911018205 CREW CHIEF (INITIALS): SAN

CPOM 911018206

WATERBODY: Otter Creek LOCATION: CR 24W Rd

COUNTY: Vigo ECOREGION: 72b SEGMENT: 49 IAS NATURAL REGION CODE: 7B

LATITUDE: 39, 32, 33 LONGITUDE: 87, 24, 50 HYDROLOGIC UNIT: 05120111

GRADIENT: 4.7 4.65 ft/mi ~~METERS/KILOMETER~~ DRAINAGE AREA: ______ SQUARE KILOMETERS TOPO MAP: F-48

HABITAT ASSESSMENT (Y or N)?: Y # JARS PER SAMPLE: ~~2~~ 1

NOTES:
Lots Cladophora ~~sp~~

$\frac{10}{2.15} = 4.65$

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
RAPID BIOASSESSMENT DATA FIELD SHEET

Waterbody Name Otter Creek Location C.R.24 W Reach/Mile Point
Latitude/Longitude County Vigo State IN Aq. Ecoregion
Station Number Investigators SAN SPW
Time Agency IDEM Hydrologic Unit Code Date 18 OCT 91
Notes Form Completed By SPW

Physical Characteristics/Water Quality Field Sheets

RIPARIAN ZONE/INSTREAM FEATURE:
Predominant Surrounding Land Use:
FOREST FIELD/PASTURE AGRICULTURAL RESIDENTIAL COMMERCIAL INDUSTRIAL OTHER
Local Watershed Erosion: NONE MODERATE HEAVY
Local Watershed NPS Pollution: NO EVIDENCE SOME POTENTIAL SOURCES OBVIOUS SOURCES
Estimated Stream Width: 19.8 m Estimated Stream Depth: Riffle .1 m Run .3 m Pool >1. m
Estimated Distance Between Riffles ___ m Estimated Distance Between Bends 50m m
High Water Mark 3 m Velocity Dam Present: YES NO Channelization YES NO
Canopy Cover: OPEN PARTLY OPEN PARTLY SHADED SHADED

SEDIMENT/SUBSTRATE:
Sediment Odors: NORMAL SEWAGE PETROLEUM CHEMICAL ANAEROBIC NONE OTHER
Sediment Oils: ABSENT SLIGHT MODERATE PROFUSE
Sediment Deposits: SLUDGE SAWDUST PAPER FIBER SAND RELICT SHELLS OTHER
Are the undersides of stones which are not deeply embedded black: YES NO

INORGANIC SUBSTRATE COMPONENTS

Substrate Type	Diameter	Percent Comp. in Area Samp.
Bedrock	—	20% 40% 60% 80% 100%
Boulder	10.0 in	20% 40% 60% 80% 100%
Cobble	2.5-10 in	20% 40% 60% 80% 100%
Gravel	0.1-2.5 in	20% 40% 60% 80% 100%
Sand	gritty	20% 40% 60% 80% 100%
Silt		20% 40% 60% 80% 100%
Clay	slick	20% 40% 60% 80% 100%

ORGANIC SUBSTRATE COMPONENTS

Substrate Type	Characteristics	Percent Comp. in Area
Detritus	Sticks, Wood Course Plant Material CPOM	20% 40% 60% 80% 100%
Muck/Mud	Black, Very Fine Organic FPOM	20% 40% 60% 80% 100%
Marl	Grey with Shell Fragments	20% 40% 60% 80% 100%

WATER QUALITY
Temperature 13.6 Dissolved Oxygen 10.0 pH 8.8 Conductivity 2K 1007 Other
Instruments Used Hydrolab 4000
Stream Type: COLDWATER WARMWATER
Water Odors: NORMAL SEWAGE PEROLEUM CHEMICAL NONE OTHER
Turbidity: CLEAR SLIGHTLY TURBID TURBID OPAQUE
OTHER

WEATHER CONDITIONS:

PHOTOGRAPH NUMBERS:

OBSERVATION AND/OR SKETCH:

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
HABITAT ASSESSMENT FIELD DATA SHEET

HABITAT PARAMETERS	EXCELLENT	GOOD	FAIR	POOR
BOTTOM SUBSTRATE/ AVAILABLE COVER (ie rubble, gravel, logs, undercut banks etc)	GT 50% Stable habitat	50% - 30% Adequite habitat	30% - 10% Less than desirable habitat	LT 10% Lack of habitat obvious
SCORE=	20 -16 ____	15 - 11 12	10 - 6 ____	5 - 0 ____
EMBEDDEDNESS				
GRAVEL, COBBLE, AND BOULDER PARTICLES HAVE ____ % OF THIER SURFACE COVERED BY FINE PARTICLES.	0 - 25%	25%-50%	50%-75%	over 75%
SCORE=	20 - 16 ____	15 -11 12	10 - 6 ____	5 - 0 ____
FLOW OR VELOCITY/DEPTH (a or b)				
a: IF FLOW LE 5 cfs: COLD:	GT 2 cfs	2-1 cfs	1-0.5 cfs	LT 0.5 cfs
WARM:	GT 5 cfs	5-2 cfs	2-1 cfs	LT 1.0 cfs
a: SCORE=	20 -16 ____	15 -11 ____	10 - 6 ____	5 - 0 ____
b: IF FLOW GT 5 cfs: VELOCITY/DEPTH 1) SLOW/DEEP 2) SLOW/SHALLOW 3) FAST/DEEP 4) FAST/SHALLOW	All present	3 of 4 present	2 of 4 present	Dominated by by one (ie pools)
b: SCORE=	20 - 16 ____	15 - 11 12	10 - 6 ____	5 - 1 ____
(slow=LT 0.3 m/s; deep=GT 0.5 m)	(Select lower score if more riffle/run missing than pools			
CHANNEL ALTERATION	Little or no enlargement of islands or point bars, and/or no channelization	Some new increase in bar formation, mostly from course gravel and/or some channelization present	Moderate deposition of new gravel, course sand on old and new bars; pools partially filled w/silt; and/or embankments on both banks.	Heavy deposites of fine material increased bar development; most pools filled w/ silt; and/or extensive channelization.
SCORE=	15 - 12 ____	11 - 8 8	7 - 4 ____	3 - 0 ____
BOTTOM SCOURING AND DEPOSITION	Less than 5% of bottom affected by scouring and deposition	5%-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	30%-50% affected Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	More than 30% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle areas.
SCORE=	15 - 12 ____	11 - 8 8	7 - 4 ____	3 - 0 ____

HABITAT ASSESSMENT FIELD DATA SHEET
(continued)

a: POOL/RIFFLE RATIO OR b: RUN/BEND RATIO	RATIO= 5 - 7 Variety of habitat Deep riffle and pools.	RATIO= 7 - 15 Adequite depth in pools and riffles Bends provide habitat.	RATIO= 15 - 25 Occasional riffle or bend. Bottom contours provide some habitat.	RATIO= GT 25 A straight stream Flat water or shallow riffle Poor Habitat.
SCORE=	15 - 12 ____	11 - 8 11	7 - 4 ____	3 - 0 ____

(Distance between a: riffles or b: distance between bends, divided by Stream Width)

BANK STABILITY	Stable. No evidence of erosion or bank failure. Side slopes generally LT 30% al Little potential for future problem	Moderate Stable. Infrequent, small areas of erosion mostly healed over Side slopes up to 40% on one bank. High erosion potin extreme floods	Moderate unstable Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks and bends. High erosion potential during extreme high flow.	Unstable. Many eroded areas Side slopes GT 60% common Raw areas frequent along straight sections
SCORE=	10 - 9 ____	8 - 6 6	5 - 3 ____	2 - 1 ____
BANK VEGETATIVE STABILITY	THE STREAMBANK SURFACES COVERED BY ____ % VEGETATION OR BOULDERS AND COBBLE. GT 80%	79% - 50%	49% - 25%	LT 25%
SCORE=	10 - 9 ____	8 - 6 7	5 - 3 ____	2 - 0 ____
[illegible]VER	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or forbes.	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings.
SCORE=	10 - 9 ____	8 - 6 8	5 - 3 ____	2 - 0 ____
TOTAL OF COLUMN SCORES	TOTAL ____	TOTAL 34	TOTAL ____	TOTAL ____

HABITAT ASSESSMENT TOTAL SCORE ____

Waterbody Name: Otter Creek
Location: 24 W Rd
Reach/Milepoint:
Latitude/Longitude:
County: Vigo
State:
Aquatic Ecoregion:

Station Number:
Investigators: S[illegible]
Date: 18 OCT 91
Time:
Agency:
Hydrologic Unit Code:
Form Completed By: S[illegible]
Reason for Survey:

Rapid Bioassessment Protocol III

Biosurvey Field Data Sheet

RELATIVE ABUNDANCE OF AQUATIC BIOTA

Periphyton	0	1	2	3	4	Slimes	0	1	2	3	4
Filamentous Algae	0	1	2	3	4	Macroinvertebrates	0	1	2	3	4
Macrophytes	0	1	2	3	4	Fish	0	1	2	3	4

0 = Absent/Not Observed 1 = Rare 2 = Common 3 = Abundant 4 = Dominant

MACROBENTHOS QUALITATIVE SAMPLE LIST (Indicate Relative Abundance: R = Rare, C = Common, A = Abundant, D = Dominant)

Porifera		Anisoptera		Chironomidae	A
Hydrozoa		Zygoptera		Plecoptera	
Platyhelminthes		Hemiptera		Ephemeroptera	D
Turbellaria		Coleoptera	A	Trichoptera	A
Hirudinea		Lepidoptera		Other	
Oligochaeta		Sialidae			
Isopoda		Corydalidae			
Amphipoda		Tipulidae	C		
Decapoda	R	Empididae			
Gastropoda		Simuliidae			
Bivalvia	D	Tabanidae			
		Culicidae			

Rare < 3 Common 3 — 9 Abundant > 10 Dominant > 50 (Estimates)

CPOM SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group)

Shredders	Total Org. in Sample

Observations

Lots Corbicula

Sphaeriidae

Ohio EPA Site Description Sheet - Fish

QHEI SCORE: 74

Stream Otter Creek Seg 49 RM ______ Date 18 OCT 91 River Code ______
Location CR 24(?) Vigo Co Crew: ______

1] SUBSTRATE (Check *ONLY* Two Substrate *TYPE BOXES*; Check all types present);

SUBSTRATE SCORE: 13

TYPE	POOL	RIFFLE		POOL	RIFFLE
☐☐-BLDER/SLABS[10]			☐☐-GRAVEL [7]	✓	✓
☐☐-BOULDER [9]			☑☐-SAND [6]	✓	✓
☐☑-COBBLE [8]	✓	✓	☐☐-BEDROCK[5]		
☐☐-HARDPAN [4]			☐☐-DETRITUS[3]	✓	
☐☐-MUCK [2]			☐☐-ARTIFIC.[0]		

TOTAL NUMBER OF SUBSTRATE TYPES: ☐ > 4 [2] ☑ <= 4 [0]

SUBSTRATE QUALITY
Substrate Origin (Check all)
☐-LIMESTONE [1] ☐-RIP/RAP [0]
☑-TILLS [1] ☐-HARDPAN [0]
☐-SANDSTONE [0]
☐-SHALE [-1]
☐-COAL FINES [-2]

Silt Cover (Check One)
☐-SILT HEAVY [-2] ☑-SILT MODERATE [-
☐ - SILT NORMAL [0] ☐ - SILT FREE [1]

Extent Of Embeddness (Check One)
☐—EXTENSIVE [-2] ☑—MODERATE [
☐—LOW[0] ☐—NONE[1]

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)
COMMENTS ______

2] INSTREAM COVER

COVER SCORE: 15

TYPE (Check *All* That Apply)
☑-UNDERCUT BANKS [1] ☑-DEEP POOLS [2] ☐-OXBOWS [1]
☑-OVERHANGING VEGETATION [1] ☑-ROOTWADS [1] ☐-AQUATIC MACROPHYTES [1]
☑-SHALLOWS (IN SLOW WATER) [1] ☑-BOULDERS [1] ☑-LOGS OR WOODY DEBRIS [1]

AMOUNT (Check *ONLY* One or check 2 and *AVERAGE*)
☐ - EXTENSIVE > 75% [11]
☑ - MODERATE 25-75% [7]
☐ - SPARSE 5-25% [3]
☐ - NEARLY ABSENT < 5% [1]

COMMENTS: ______

3] CHANNEL MORPHOLOGY: (Check *ONLY* One PER Category OR check 2 and *AVERAGE*)

CHANNEL: 13

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☐ - NONE [6]	☐ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☑ - MODERATE [3]	☑ - GOOD [5]	☐ - RECOVERED [4]	☑ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☑ - RECOVERING [3]	☐ - LOW [1]	☑ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☐ - BANK SHAPING
				☐ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: ______

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank)

RIPARIAN: 9

"River Right Looking Downstream"

RIPARIAN WIDTH L R (Per Bank)	EROSION/RUNOFF - FLOOD PLAIN QUALITY L R (Most Predominant Per Bank)	L R (Per Bank)	BANK EROSION
☑☑-WIDE>50m [4]	☑☑-FOREST, SWAMP [3]	☐☐-URBAN OR INDUSTRIAL[0]	☐ ☐-NONE OR LITTLE [3]
☐☐-MODERATE 10-50 [3]	☐☐-OPEN PASTURE/ ROWCROP[0]	☐☐-SHRUB OR OLD FIELD[2]	☑ ☑-MODERATE [2]
☐☐-NARROW 5-10m [2]	☐☐- RESID.,PARK,NEW FIELD [1]	☐☐-CONSERV. TILLAGE [1]	☐ ☐-HEAVY OR SEVERE[1]
☐☐-VERY NARROW 1-5m [1]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐-NONE[0]			

COMMENTS: ______

POOL/GLIDE AND RIFFLE/RUN QUALITY

POOL: 9

MAX. DEPTH (Check 1)
☑ >1m [6]
☐- 0.7-1m [4]
☐- 0.4-0.7m [2]
☐- < 0.4m [1]
☐—<0.2m [Pool = 0]

MORPHOLOGY (Check 1)
☑-POOL WIDTH > RIFFLE WIDTH [2]
☐-POOL WIDTH = RIFFLE WIDTH [1]
☐-POOL WIDTH < RIFFLE W. [0]

POOL/RUN/RIFFLE CURRENT VELOCITY (Check *All* That Apply)
☐-TORRENTIAL[-1] ☐-EDDIES[1]
☐-FAST[1] ☐-INTERSTITIAL[-1]
☑-MODERATE [1] ☐-INTERMITTENT[-2]
☐-SLOW [1]

☐-NO POOL[0]

COMMENTS: ______

RIFFLE: 5

RIFFLE/RUN DEPTH
☐ - GENERALLY >10 cm,MAX>50 [4]
☑ - GENERALLY >10 cm,MAX<50 [3]
☐ - GENERALLY 5-10 cm [1]
☐ - GENERALLY < 5 cm [Riffle = 0]

RIFFLE/RUN SUBSTRATE
☑-STABLE (e.g.,Cobble, Boulder) [2]
☑-MOD. STABLE (e.g.,Pea Gravel) [1]
☐-UNSTABLE (Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
☐-EXTENSIVE [-1] ☑-MODERATE[0]
☐-LOW. [1] ☐-NONE[2]

☐-NO RIFFLE[0]

COMMENTS ______

GRADIENT: 10

6] Gradient (feet/mile): 4.65 (4.7) %POOL: 5 %RIFFLE: 1 %RUN: 74

@ 19.8 mi

EPA 4520

Is Reach Representative of Stream? (Y/N) Y If Not:

Additional Comments/Pollution Impacts:

	GEAR	DISTANC	WATER CLARITY	WATER STAGE
FIRST PASS				
SECOND PASS				
THIRD PASS				

SUBJECTIVE RATING (1-10): 8

AESTHETIC RATING (1-10): 8

CANOPY (%OPEN) 60%

GRADIENT: O–LOW ✓ O–MODERATE O–HIGH

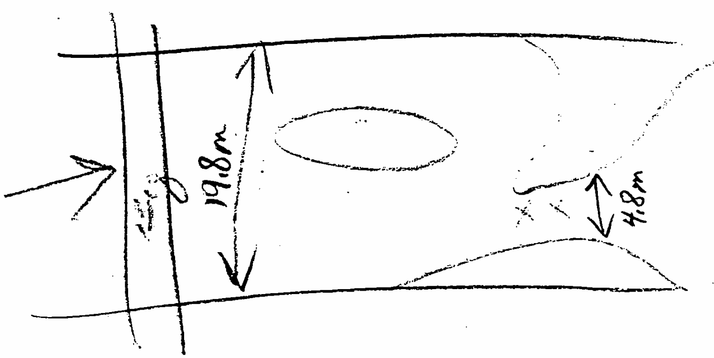
PHOTOS: One

STREAM MEASUREMENTS: AVERAGE WIDTH: 19.8 AVERAGE DEPTH: .2 MAX. DEPTH .71

LENGTH	WIDTH	DEPTHS ▷										POOL:GLD:RIF:RUN

CROSS-SECTIONS OF STREAM

DRAWING OF STREAM



INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL MONITORING
RAPID BIOASSESSMENT PROTOCOL III
MACROIVERTEBRATE COLLECTIONS
SITE INFORMATION

COLLECTION DATE: 10 / 18 / 91 BMS SAMPLE #: KICK 911018203 CREW CHIEF (INITIALS): SAN

CPOM 911018204

WATERBODY: Otter Creek LOCATION: U.S (Business) 41

COUNTY: Vigo ECOREGION: 72M SEGMENT: 49 IDNR NATURAL REGION CODE: 7B

LATITUDE: 39 / 31 / 37 LONGITUDE: 87 / 22 / 14 HYDROLOGIC UNIT: 05120111

GRADIENT: 4.7 4.67 ft/mile ~~METERS/KILOMETER~~ DRAINAGE AREA: ______ SQUARE KILOMETERS TOPO MAP: F 49

HABITAT ASSESSMENT (Y or N)?: Y # JARS PER SAMPLE: 2

NOTES:

$\frac{10 \text{ ft}}{2.\ldots} = 4.67$

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
RAPID BIOASSESSMENT DATA FIELD SHEET

Waterbody Name Otter Creek   Location Business 41   Reach/Mile Point
Latitude/Longitude   County Vigo   State IN   Aq. Ecoregion
Station Number   Investigators
Time   Agency IDEM   Hydrologic Unit Code   Date 18 OCT 91
Notes   Form Completed By

Physical Characteristics/Water Quality Field Sheets

RIPARIAN ZONE/INSTREAM FEATURE:
Predominant Surrounding Land Use:
FOREST   FIELD/PASTURE   AGRICULTURAL   RESIDENTIAL   COMMERCIAL   INDUSTRIAL   OTHER
Local Watershed Erosion: NONE   MODERATE   HEAVY
Local Watershed NPS Pollution: NO EVIDENCE   SOME POTENTIAL SOURCES   OBVIOUS SOURCES
Estimated Stream Width: 14.5 m   Estimated Stream Depth: Riffle .05 m   Run .3 m   Pool >1 m
Estimated Distance Between Riffles — m   Estimated Distance Between Bends 100 m
High Water Mark 1 m   Velocity
Canopy Cover: OPEN   PARTLY OPEN   PARTLY SHADED   SHADED   Dam Present: YES   NO   Channelization YES   NO

SEDIMENT/SUBSTRATE:
Sediment Odors: NORMAL   SEWAGE   PETROLEUM   CHEMICAL   ANAEROBIC   NONE   OTHER
Sediment Oils: ABSENT   SLIGHT   MODERATE   PROFUSE
Sediment Deposits: SLUDGE   SAWDUST   PAPER FIBER   SAND   RELICT SHELLS   OTHER
Are the undersides of stones which are not deeply embedded black: YES   NO

INORGANIC SUBSTRATE COMPONENTS

Substrate Type	Diameter	Percent Comp. in Area Samp.
Bedrock	—	20% 40% 60% 80% 100%
Boulder	10.0 in	20% 40% 60% 80% 100%
Cobble	2.5-10 in	20% 40% 60% 80% 100%
Gravel	0.1-2.5 in	20% 40% 60% 80% 100%
Sand	gritty	20% 40% 60% 80% 100%
Silt		20% 40% 60% 80% 100%
Clay	slick	20% 40% 60% 80% 100%

ORGANIC SUBSTRATE COMPONENTS

Substrate Type	Characteristics	Percent Comp. in Area
Detritus	Sticks, Wood Course Plant Material CPOM	20% 40% 60% 80% 100%
Muck/Mud	Black, Very Fine Organic FPOM	20% 40% 60% 80% 100%
Marl	Grey with Shell Fragments	20% 40% 60% 80% 100%

WATER QUALITY
Temperature 12.6   Dissolved Oxygen 8.0   pH 7.4   Conductivity 2K 1059   Other
Instruments Used 4000 Hydrolab
Stream Type: COLDWATER   WARMWATER
Water Odors: NORMAL   SEWAGE   PETROLEUM   CHEMICAL   NONE   OTHER
Turbidity: CLEAR   SLIGHTLY TURBID   TURBID   OPAQUE
OTHER

WEATHER CONDITIONS:

PHOTOGRAPH NUMBERS:

OBSERVATION AND/OR SKETCH:

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
HABITAT ASSESSMENT FIELD DATA SHEET

HABITAT PARAMETERS	EXCELLENT	GOOD	FAIR	POOR
BOTTOM SUBSTRATE/ AVAILABLE COVER (ie rubble,gravel, logs, undercut banks etc)	GT 50% Stable habitat	50% - 30% Adequite habitat	30% - 10% Less than desireable habitat	LT 10% Lack of habitat obvious
SCORE=	20 -16 ____	15 - 11 ____	10 - 6 10	5 - 0 ____
EMBEDDEDNESS GRAVEL, COBBLE, AND BOULDER PARTICLES HAVE ____ % OF THIER SURFACE COVERED BY FINE PARTICLES.	0 - 25%	25%-50%	50%-75%	over 75%
SCORE=	20 - 16 ____	15 -11 ____	10 - 6 10	5 - 0 ____
LOW OR VELOCITY/DEPTH (a or b) a: IF FLOW LE 5 cfs: COLD:	GT 2 cfs	2-1 cfs	1-0.5 cfs	LT 0.5 cfs
WARM:	GT 5 cfs	5-2 cfs	2-1 cfs	LT 1.0 cfs
a: SCORE=	20 -16 ____	15 -11 ____	10 - 6 ____	5 - 0 ____
b: IF FLOW GT 5 cfs: VELOCITY/DEPTH 1) SLOW/DEEP 2) SLOW/ SHALLOW 3) FAST/DEEP 4) FAST/SHALLOW	All present	3 of 4 present	2 of 4 present	Dominated by by one (ie pools)
b: SCORE=	20 - 16 ____	15 - 11 11	10 - 6 ____	5 - 1 ____

low=LT 0.3 m/s; deep=GT 0.5 m) (Select lower score if more riffle/run missing than pools

ANNEL ALTERATION	Little or no enlargement of islands or point bars,and/or no channelization	Some new increase in bar formation, mostly from course gravel and/or some channelization present	Moderate deposition of new gravel,course sand on old and new bars; pools partially filled w/silt;and/ or embankments on both banks.	Heavy deposites of fine material increased bar development; most pools filled w/ silt; and/or extensive channelization.
SCORE=	15 - 12 ____	11 - 8 ____	7 - 4 5	3 - 0 ____
TOM SCOURING AND OSITION	Less than 5% of bottom affected by scouring and deposition	5%-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	30%-50% affected Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	More than 30% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle areas.
SCORE=	15 - 12 ____	11 - 8 ____	7 - 4 5	3 - 0 ____

HABITAT ASSESSMENT FIELD DATA SHEET
(continued)

a: POOL/RIFFLE RATIO OR b: RUN/BEND-RATIO	RATIO= 5 - 7 Variety of habitat Deep riffle and pools.	RATIO= 7 - 15 Adequite depth in pools and riffles Bends provide habitat.	RATIO= 15 - 25 Occasional riffle or bend. Bottom contours provide some habitat.	RATIO= GT 25 A straight stream Flat water or shallow riffle Poor Habitat.
SCORE=	15 - 12 ___	11 - 8 8	7 - 4 ___	3 - 0 ___

(Distance between a: riffles or b: distance between bends, divided by Stream Width)

BANK STABILITY	Stable. No evidence of erosion or bank failure. Side slopes generally LT 30% al Little potential for future problem	Moderate Stable. Infrequent, small areas of erosion mostly healed over Side slopes up to 40% on one bank. High erosion pot- in extreme floods	Moderate unstable Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks and bends. ential during extreme high flow.	Unstable. Many eroded areas Side slopes GT 60% common Raw areas frequent along straight sections
SCORE=	10 - 9 ___	8 - 6 7	5 - 3 ___	2 - 1 ___

..K VEGETATIVE STABILITY	THE STREAMBANK SURFACES COVERED BY ___ % VEGETATION OR BOULDERS AND COBBLE. GT 80%	79% - 50%	49% - 25%	LT 25%
SCORE=	10 - 9 ___	8 - 6 ___	5 - 3 4	2 - 0 ___

STREAMSIDE COVER	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or forbes.	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings.
SCORE=	10 - 9 ___	8 - 6 ___	5 - 3 4	2 - 0 ___

TOTAL OF COLUMN SCORES	TOTAL ___	TOTAL 26	TOTAL 38	TOTAL ___

HABITAT ASSESSMENT TOTAL SCORE 64

Ohio EPA Site Description Sheet - Fish

QHEI SCORE: 67

Stream Otter Creek RM ____ Date 18 Oct 91 River Code ____

Location Vigo Bursmers 41 Crew: ____

1] SUBSTRATE (Check *ONLY* Two Substrate *TYPE BOXES; Check all types present*);

TYPE — POOL RIFFLE — POOL RIFFLE

- ☐☐-BLDER /SLABS[10] ____ ____ ☐☐-GRAVEL [7] ✓ ✓
- ☐☐-BOULDER [9] ✓ ✓ ☐☐-SAND [6] ✓ ✓
- ☐☐-COBBLE [8] ✓ ✓ ☐☐-BEDROCK[5] ____ ____
- ☐☐-HARDPAN [4] ____ ____ ☐☐-DETRITUS[3] ✓ ____
- ☐☐-MUCK [2] ____ ____ ☐☐-ARTIFIC.[0] ✓ ____

TOTAL NUMBER OF SUBSTRATE TYPES: ☐-> 4 [2] ☐-<= 4 [0]

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)

COMMENTS ____

SUBSTRATE QUALITY

Substrate Origin (Check all)

- ☐-LIMESTONE [1]
- ☐-RIP/RAP [0]
- ☐-TILLS [1]
- ☐-HARDPAN [0]
- ☐-SANDSTONE [0]
- ☐-SHALE [-1]
- ☐-COAL FINES [-2]

Silt Cover (Check One)

- ☐-SILT HEAVY [-2]
- ☐-SILT MODERATE
- ☐-SILT NORMAL [0]
- ☐-SILT FREE

Extent Of Embeddedness (Check One)

- ☐-EXTENSIVE [-2]
- ☐-MODERATE
- ☐-LOW[0]
- ☐-NONE[1]

SUBSTRATE SCORE: ____

2] INSTREAM COVER

TYPE (Check *All* That Apply)

- ☐-UNDERCUT BANKS [1]
- ☐-OVERHANGING VEGETATION [1]
- ☐-SHALLOWS (IN SLOW WATER) [1]
- ☐-DEEP POOLS [2]
- ☐-ROOTWADS [1]
- ☐-BOULDERS [1]
- ☐-OXBOWS [1]
- ☐-AQUATIC MACROPHYTES [1]
- ☐-LOGS OR WOODY DEBRIS [1]

COMMENTS: ____

COVER SCORE: ____

AMOUNT(Check *ONLY* One or check 2 and *AVERAGE*)

- ☐ - EXTENSIVE > 75% [11]
- ☐ - MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

3] CHANNEL MORPHOLOGY: (Check *ONLY* One PER Category OR check 2 and *AVERAGE*)

CHANNEL: ____

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐ - HIGH [4]	☐ - EXCELLENT [7]	☐ - NONE [6]	☐ - HIGH [3]	☐ - SNAGGING	☐ - IMPOUND.
☐ - MODERATE [3]	☐ - GOOD [5]	☐ - RECOVERED [4]	☐ - MODERATE [2]	☐ - RELOCATION	☐ - ISLANDS
☐ - LOW [2]	☐ - FAIR [3]	☐ - RECOVERING [3]	☐ - LOW [1]	☐ - CANOPY REMOVAL	☐ - LEVEED
☐ - NONE [1]	☐ - POOR [1]	☐ - RECENT OR NO RECOVERY [1]		☐ - DREDGING	☐ - BANK SHAPING
				☐ - ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: ____

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank)

"River Right Looking Downstream"

RIPARIAN: ____

RIPARIAN WIDTH

L R (Per Bank)

- ☐☐-WIDE>50m [4]
- ☐☐-MODERATE 10-50 [3]
- ☐☐-NARROW 5-10m [2]
- ☐☐-VERY NARROW 1-5m [1]
- ☐☐-NONE[0]

EROSION/RUNOFF - FLOOD PLAIN QUALITY

L R (Most Predominant Per Bank)

- ☐☐-FOREST, SWAMP [3]
- ☐☐-OPEN PASTURE/ ROWCROP[0]
- ☐☐-RESID.,PARK,NEW FIELD [1]
- ☐☐-FENCED PASTURE [1]

L R (Per Bank)

- ☐☐-URBAN OR INDUSTRIAL[0]
- ☐☐-SHRUB OR OLD FIELD[2]
- ☐☐-CONSERV. TILLAGE [1]
- ☐☐-MINING/CONSTRUCTION [0]

BANK EROSION

- ☐ ☐-NONE OR LITTLE [3]
- ☐ ☐-MODERATE [2]
- ☐ ☐-HEAVY OR SEVERE[1]

COMMENTS: ____

POOL/GLIDE AND RIFFLE/RUN QUALITY

POOL: ____

MAX. DEPTH (Check 1)

- ☐->1m [6]
- ☐-0.7-1m [4]
- ☐-0.4-0.7m [2]
- ☐-< 0.4m [1]
- ☐-<0.2m [Pool = 0]

MORPHOLOGY (Check 1)

- ☐-POOL WIDTH > RIFFLE WIDTH [2]
- ☐-POOL WIDTH = RIFFLE WIDTH [1]
- ☐-POOL WIDTH < RIFFLE W. [0]

POOL/RUN/RIFFLE CURRENT VELOCITY (Check *All* That Apply)

- ☐-TORRENTIAL[-1]
- ☐-FAST[1]
- ☐-MODERATE [1]
- ☐-SLOW [1]
- ☐-EDDIES[1]
- ☐-INTERSTITIAL[-1]
- ☐-INTERMITTENT[-2]

☐-NO POOL

COMMENTS: ____

RIFFLE: ____

RIFFLE/RUN DEPTH

- ☐ - GENERALLY >10 cm,MAX>50 [4]
- ☐ - GENERALLY >10 cm,MAX<50 [3]
- ☐ - GENERALLY 5-10 cm [1]
- ☐ - GENERALLY < 5 cm [Riffle = 0]

RIFFLE/RUN SUBSTRATE

- ☐-STABLE (e.g.,Cobble, Boulder) [2]
- ☐-MOD. STABLE (e.g.,Pea Gravel) [1]
- ☐-UNSTABLE (Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS

- ☐-EXTENSIVE [-1]
- ☐-MODERATE[0]
- ☐-LOW. [1]
- ☐-NONE[2]

☐-NO RIFFLE

COMMENTS ____

GRADIENT: 1

6] Gradient (feet/mile): 4.67 (4.7) %POOL: 5 %RIFFLE: 1 %RUN: 94

EPA 4520

@ 14.5

Is Reach Representative of Stream? (Y/N)______ If Not: ______

Additional Comments/Pollution Impacts: ______

	GEAR	DISTANC	WATER CLARITY	WATER STAGE
FIRST PASS				
SECOND PASS				
THIRD PASS				

SUBJECTIVE RATING (1-10): $\boxed{6}$

AESTHETIC RATING (1-10): $\boxed{4}$

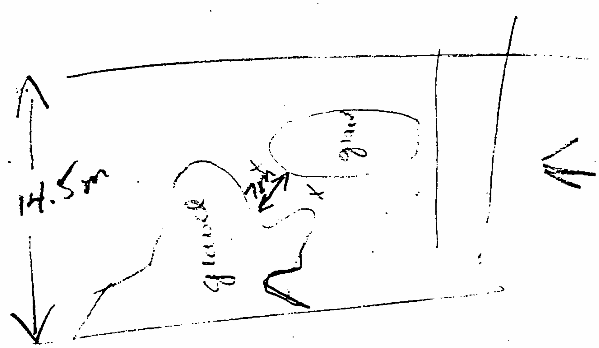
CANOPY (%OPEN) 100 GRADIENT: ~~LOW~~ O-MODERATE O-HIGH PHOTOS: #22

STREAM MEASUREMENTS: AVERAGE WIDTH: 14.5 AVERAGE DEPTH: .4 MAX DEPTH >1

LENGTH	WIDTH	DEPTHS ▷									POOL:GLD:RIF:RUN

CROSS-SECTIONS OF STREAM

DRAWING OF STREAM



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Page: 1 of: ___
Collection Date: 3 / Apr / 95

Rapid Bioassment Protocol III
Macroinvertebrate Collections Site Information

2353 Yeager Rd. Ste. 11 • West Lafayette, IN 47906-1827 • Phone (317) 497-4398

LHR Sample #: ___ ___ Crew Cheif: SPW

Duplicate#: ___ ___ Crew: SPW

Waterbody: Otter Cr. Location: Old Mill Dam

County: Vigo Ecoregion: ___ Segment: ___ IAS Natural Region Code: ___

Latitude: ___:___:___ Longitude: ___:___:___ Hydrologic Unit: ___

Easting: ___ Northing: ___ Zone: 16

Gradient: ___ (feet/mile) Drainage Area: ___ (miles^2) Topo Map: ___

Habitat Assessment (Y or N?): Y # Jars/Sample: 1

Notes: lots of Corbicula. Sandy soil – sand is everywhere.

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Page: 2 of:

Physical Characteristics/Water Quality Data Sheet

Waterbody: Otter Cr. Location: Old Mill Dam Reach/Milepoint:
County: Vigo State: IN Investigators: SPW Date: 3 /Apr / 95
Time: 16:40 Hydrologic Unit: Form Completed by: SPW
Notes:

Riparian Zone/Instream Feature

Predominant Surrounding Land Use: Forest Field/Pasture Agriculture Residential Commercial Industrial
Other:
Local Watershed NPS Pollution: No Evidence Some Potential Sources Obvious Sources
Local Watershed Erosion: None Moderate Heavy
Est. Stream Width: 20 m **Est. Stream Depth:** Riffle 0.1 m Run 0.2 m Pool 1 m
Est. Distance Between Riffles: 100 m **Est. Distance Between Bends:** 100 m
High Water Mark: 2.25 m **Velocity:** NA feet/second
Channelization: Yes No **Dam Present:** Yes No
Canopy Cover: 100-80% open 79-60% open 59-40% open 39-20% open 19-0% open

Sediment/Substrate

Sediment Odors: Normal Sewage Petroleum Chemical Anaerobic None
Other
Sediment Oils: Absent Slight Moderate Profuse
Sediment Deposits: Sludge Sawdust Paper Fiber Sand Relict Shells Other
Are the undersides of stones which are not deeply embedded black? Yes No

Inorganic Substrate Component

Substrate Type	Diameter	% Comp. in Area Sampled
Bedrock		20 40 60 80 100
Boulder	>10 in.	20 40 60 80 100
Cobble	2.5-10 in.	20 40 60 80 100
Gravel	0.1-2.5 in.	20 40 60 80 100
Sand	gritty	20 40 60 80 100
Silt		20 40 60 80 100
Clay	slick	20 40 60 80 100

Organic Substrate Components

Substrate Type	Characteristics	% Comp. in Area Sampled
Detritus	Sticks, wood -	20 40 60 80 100
	Course plant (CPOM) -	20 40 60 80 100
Muck/Mud	Black, very fine (FPOM) -	20 40 60 80 100
Marl	Gray w/shell fragments -	20 40 60 80 100

Water Quality

Temperature: NA **Disolved Oxygen:** NA **pH:** NA **Conductivity:** NA **ORP:** NA **Salinity:** NA
Other Parameters: NA
Instruments Used: NA
Stream Type: Coldwater Warmwater **Water Odors:** Normal Sewage Petroleum Chemical None Other
Water Surface Oils: Slick Sheen Globs Flocks None **Turbidity:** Clear Slight Turbid Opaque
Other Observations:

Weather Conditions

Photo #: 19 Role: 3
Air Temperature: 55 °C °F **Barometric Pressure:** mm Hg **Rain?** Light **Cloud Cover:** 100%

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Habitat Assessment Field Data Sheet

Waterbody: Otter Cr. Location: Old mill Dam Date: 3 / Apr / 95
County: Vigo State: IN Form Completed by: SPW
Notes:

Habitat Parameters	Excellent	Good	Fair	Poor
Bottom Substrate/ Available Cover (i.e. logs, roots, undercut banks, rubble, gravel) **Score:**	**> 50%** Stable habitat. **20-16** 17	**50-30%** Adequate habitat. **15-11**____	**30-10%** Less than desirable habitat. **10-6**____	**< 10%** Lack of habitat obvious. **5-0**____
Embeddedness Gravel, cobble, and boulders have ____% of their surface covered by fine particles. **Score:**	**0-25%** **20-16** 17	**25-50%** **15-11**____	**50-75%** **10-6**____	**Over 75%** **5-1**____
Flow or Velocity/Depth (a or b) **a: If flow <= 5cfs:** Cold Warm **a: Score:**	> 2cfs > 5cfs **20-16**____	2-1cfs 5-2cfs **15-11**____	1-0.5cfs 2-1cfs **10-6**____	< 0.5cfs < 1cfs **5-1**____
b: If flow > 5cfs: Velocity/Depth 1) Slow/Deep 2) Slow/Shallow ✓ 3) Fast/Deep 4) Fast/Shallow ✓ **b: Score:** **Note:** Slow is < 0.3m/s; Deep is > 0.5m	**All present** **20-16**____	**3 of 4 present*** **15-11**____	**2 of 4 present*** **10-6** 10	**Dominated by one*** (i.e. pools) **5-0**____ *missing riffles or runs scores lower than missing pools
Channel Alteration **Score:**	Little or no enlargement of islands or point bars and/or no channelization. **15-12**____	Some new increase in bar formation, mostly from course gravel and/or some channelization present. **11-8** 11	Moderate deposition of new gravel, course sand on old & new bars; pools partially filled with silt; and/or reenforced embankments on both banks. **7-4**____	Heavy deposits of fine material, increased bar development; most pools filled with silt; and/or extensive channelization. **3-0**____

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H. A. Field Sheet (cont'd) Page: 6 of: ____

Habitat Parameters	Excellent	Good	Fair	Poor
Bottom Scouring & Deposition **Score:**	Less than 5% of bottom affected by scouring & deposition. 15-12 14	5-30% affected. Scour at constrictions & where grades steepen. Some deposition in pools. 11-8 ____	30-50% affected. Deposits & scour at obstructions, constrictions & bends. Some filling of pools. 7-4 ____	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle areas. 3-0 ____
a: Pool/Riffle Ratio or **b: Run/Bend Ratio** Ratio is the distance between a: riffles or distance between b: bends divided by stream width using most dominant feature. **Score:**	**Ratio: 5-7** Variety of habitat. Deep riffles & pools. 15-12 ____	**Ratio: 7-15** Adequate depth in pools & riffles. Bends provide habitat. 11-8 10	**Ratio: 15-25** Occaisional riffle or bend. Bottom contours provide some habitat. 7-4 ____	**Ratio: > 25** A straight stream. Flat water or shallow riffles. Poor habitat. 3-0 ____
Bank Stability Adjustments should be made for steep, raw clay banks less susceptable to erosion than some soil types. **Score:**	Stable. No evidence of erosion or bank failure. Side slopes generally < 30%. Little potential for future problem. 10-9 ____	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight erosion potential in extreme floods. 8-6 8	Moderately unstable. Moderate frequency & size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme high flow. 5-3 ____	Unstable. Many eroded areas. Side slopes > 60% common. Raw areas frequent along straight sections & bends. 2-0 ____
Bank Vegetation Stability Streambank surfaces covered by ____% vegetation, boulders, and cobble. **Score:**	**> 80%** 10-9 ____	**79-50%** 8-6 8	**49-25%** 5-3 ____	**< 25%** 2-0 ____
Streamside Cover **Score:**	Dominant vegetation is shrub. 10-9 ____	**Dominant vegetation is of tree form.** 8-6 8	**Dominant vegetation is grass or forbes.** 5-3 ____	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2-0 ____

Column Scores: Total 48 Total 45 Total 10 Total ____

Habitat Assessment Total Score 103

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Ohio EPA QHEI Field Sheet

QHEI Score: 76.5

Waterbody: Otter Cr. Location: Old Mill Dam Date: 3 / Apr / 95

County: Vigo State: IN Form Completed by: SPW

1-Substrate (20) (Check ONLY two substrate TYPE BOXES; check all types present) **Substrate Score : 19**

TYPE	Pool/Riffle	TYPE	Pool/Riffle	Substrate Origin (check all)	Silt Cover (check one)
☐☑Boulder/Slabs(10)	✓/✓	☐☐Gravel(7)	✓/✓	☑Limestone(1)	☐Silt heavy(-2)
☐☐Boulder(9)	/✓	☑☐Sand(6)	✓/	☐Tills(1)	☐Silt moderate(-1)
☐☐Cobble(8)	✓/✓	☐☐Bedrock(5)	/✓	☐Sandstone(0)	☑Silt normal(0)
☐☐Hardpan(4)	/	☐☐Detritus(3)	/	☐Shale(-1)	☐Silt free(1)
☐☐Muck(2)	/	☐☐Artificial(0)	/	☐Rip/Rap(0)	Embeddedness (check one)
Total number of Substrate Types: ☑> 4(2) ☐<= 4(0)				☐Hardpan(0)	☐Extensive(-2)
				☐Coal fines(-2)	☐Moderate(-1)
					☑Low(0)
					☐None(1)

NOTE: Ignore sludge that originates from point sources; score based on natural substrates.

Comments:

2-Instream Cover (20) **Cover Score : 12**

TYPE (check ALL that apply)

☐Undercut banks(1) ☐Overhanging vegetation(1) ☑Shallows (in slow water)(1)
☑Deep pools(2) ☐Rootwads(1) ☑Boulders(1)
☐Oxbows(2) ☑Aquatic macrophytes(1) ☐Logs and woody debris(1)

Amount (check ONLY one OR two and AVERAGE)
☐Extensive > 75% (11)
☑Moderate 75-25% (7)
☐Sparse 25-5% (3)
☐Nearly absent < 5% (1)

Comments:

3-Channel Morphology (20) (check ONLY one per category OR two and AVERAGE) **Channel Score : 16**

Sinuosity	Development	Channelization	Stability	Modifications/Other	
☐High(4)	☑Excellent(7)	☐None(6)	☐High(3)	☐Snagging	☐Impound
☑Moderate(3)	☐Good(5)	☑Recovered(4)	☑Moderate(2)	☐Relocation	☐Islands
☐Low(2)	☐Fair(3)	☐Recovering(3)	☐Low(1)	☑Canopy removal	☐Leveed
☐None(1)	☐Poor(1)	☐Recent or no recovery(1)		☐Dredging	☐Bank shaping
				☐One side channel modifications	

Comments:

4-Riparian Zone & Bank Erosion (10) (check ONLY one per category OR two and average per bank) **RiparianScore : 6.5**

Riparian width LR (per bank)*	Erosion/Runoff - Floodplain quality LR (most predominant per bank)	LR	Bank erosion LR (per bank)
☐☐Wide > 50m(4)	☐☐Forest,swamp(3)	☐☐Urban or industrial(0)	☐☑None or little(3)
☑☑Moderate 10-50m(3)	☐☐Open pasture/Rowcrop(0)	☐☐Shrub or old field(2)	☑☐Moderate(2)
☐☐Narrow 5-10m(2)	☑☑Residential, park, new field(1)	☐☐Conservation tillage(1)	☐☐Heavy or severe(1)
☐☐Very narrow 1-5m(1)	☐☐Fenced pasture(1)	☐☐Mining, construction(0)	
☐☐None (0)			

*Left/Right banks looking downstream

Comments:

5-Pool/Glide & Riffle/Run Quality (12) **Pool Score : 7**

Max. pool depth (check one)	Morphology (check one	Pool/Run/Riffle current velocity (check ALL that apply)	
☐> 1m(6)	☐Pool width > riffle width(2)	☐Torrential(-1)	☑Eddies(1)
☑0.7-1m(4)	☐Pool width = riffle width(1)	☐Fast(1)	☐Interstitial(-1)
☐0.4-0.7m(2)	☑Pool width < riffle width(0)	☑Moderate(1)	☐Intermittent(-2)
☐< 0.4m(1)		☑Slow(1)	
☐< 0.2m (pool = 0)*			

*☐No pool(0)

Comments:

Riffle Score : 6

Riffle/run depth (check one)	Riffle/run substrate	Riffle/run embeddedness
☐Generally > 10cm, Max.> 50cm(4)	☑Stable- e.g., cobble, boulder(2)	☐Extensive(-1)
☑Generally > 10cm, Max.< 50cm 3)	☐Mod. stable- e.g., pea gravel(1)	☐Moderate(0)
☐ Generally 5-10cm(1)	☐Unstable- e.g., sand, gravel(0)	☑Low(1)
☐ Generally < 5cm (riffle = 0)*		☐None(2)

*☐No riffle(0)

Comments:

6-Gradient (10) Gradient: ______ (ft/mi) ☐Low ☑Moderate ☐High **Gradient Score : 10**

Average width: 20 (m) % Pool 30
Average depth: 0.2 (m) % Riffle 50
Maximum depth: 2 (m) % Run 20

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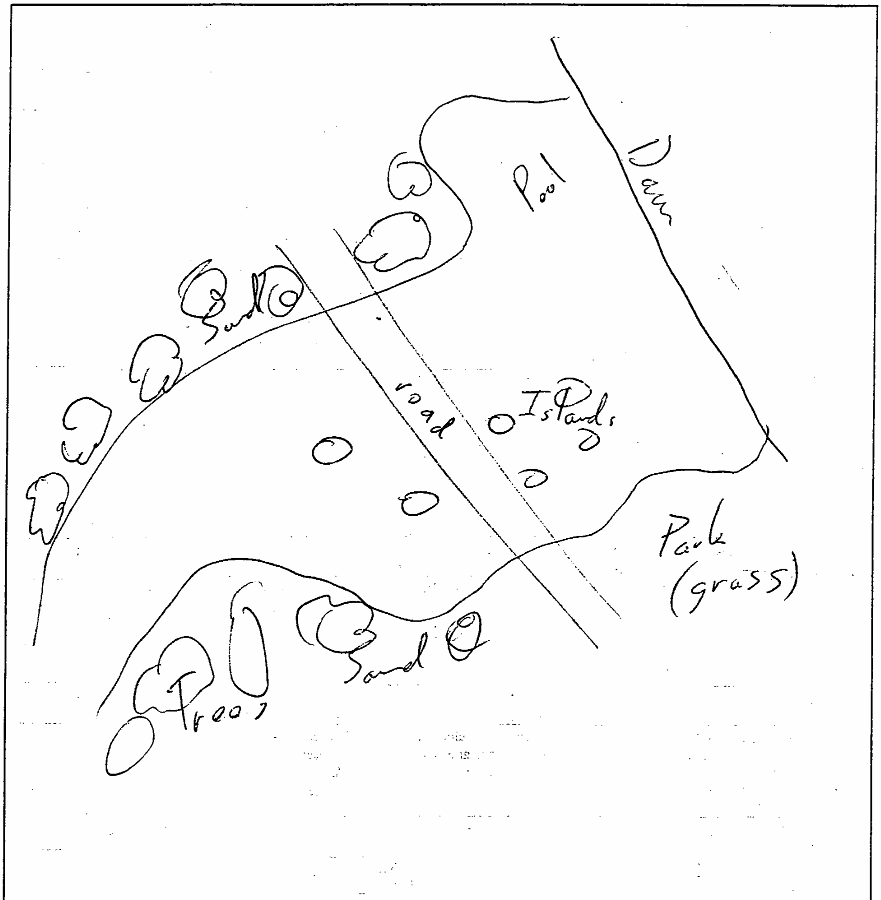
QHEI Field Sheet (cont'd) Page: 8 of: 10

Canopy (% open): 80 Subjective rating (1-10) 10

Photos: Y Aesthetic rating (1-10) 10

Additional comments/Pollution/Impacts:

Drawing of Site



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Page: 3 of:____

Rapid Bioassessment Protocol III - Subjective Biosurvey Field Sheet

Waterbody: Otter Cr. Location: Old Mill Dam Reach/Milepoint:________
County: Vigo State: IN Investigators: SPW Date: 3 14 Apr 1995
Time: 16:50 Hydrologic Unit:____________ Form Completed by: SPW
Reason for survey: Otter Cr. Biomonitoring for IDNR Lake and River Enhancement Program

Relative Abundance of Aquatic Biota

Periphyton	0	1	2	3	4
Filamentous Algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Slimes	0	1	2	3	4
Macroinvertebrates	0	1	2	3	4

0 = Absent/Not Observed 1 = Rare 2 = Common 3 = Abundant 4 = Dominant

Macrobenthos Qualitative Sample List (indicate abundance; R = Rare C = Common A = Abundant D = Dominant)*

Porifera	Anisoptera	Coleoptera
Hydrozoa	Zygoptera	
Platyhelminthes	Hemiptera	Ephemeroptera
Turbellaria	Lepidoptera	
Hirudinea	Sialidae	Tricoptera
Oligochaeta	Corydalidae	
Isopoda	Chironomidae	Plecoptera
Amphipoda	Tipulidae	
Decapoda	Empididae	Other
Gastropoda	Simulidae	Corbicula A
Bivalvia	Tabanidae	
	Culicidae	

*Rare < 3 Common 3-10 Abundant 10-50 Dominant > 50 (estimate)

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Impairment Assessment Sheet

1. Detection of Impairment: Impairment Detected No Impairment Detected (stop here)

2. Biological Impairment Indicator:

Benthic Macroinvertebrates

_____ Absence of EPT taxa
_____ Dominance of tolerant group
_____ Low benthic abundance
_____ Low taxa richness
_____ Other

Other Aquatic Communities

_____ Periphyton:
_____ Filamentous
_____ Other
_____ Macrophytes
_____ Slimes
_____ Fish

3. Brief description of the problem: ____________________

Year & date of previous surveys: ____________________
Survey data available in: ____________________

4. Causes: (indicate major cause) **Organic Enrichment** **Toxicants** **Flow** **Habitat Limitations**
Other: ____________________

5. Estimated areal extent of problem and length of stream reach affected: ____________________

6. Suspected sources of problem: (i.e., name, type of facility, location)

_____ Point source discharge
_____ Construction site runoff
_____ Combined sewer outfall
_____ Silvicultural runoff
_____ Animal feedlot
_____ Agricultural runoff
_____ Urban runoff
_____ Groundwater
_____ Other
_____ Unknown

Briefly explain:

Observations and/or sketch:

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OWM-BIOLOGICAL MONITORING
RAPID BIOASSESSMENT PROTOCOL III
MACROIVERTEBRATE COLLECTIONS
SITE INFORMATION

COLLECTION DATE: 10/18/91 BMS SAMPLE #: KICK 91101820 1 CREW CHIEF (INITIALS): SAN
CPOM 9110 18202

WATERBODY: North Branch Otter Creek LOCATION: Private Br. NE 1/4 Sec 22

COUNTY: Vigo ECOREGION: 72G SEGMENT: 49 IN NATURAL REGION CODE: 7B

LATITUDE: 39, 33, 35 LONGITUDE: 87, 15, 31 HYDROLOGIC UNIT: 05120111

8.9
GRADIENT: 8.93 METERS/KILOMETER DRAINAGE AREA: ______ SQUARE KILOMETERS TOPO MAP: F-49

HABITAT ASSESSMENT (Y or N)?: Y # JARS PER SAMPLE: ~~2~~ 1

NOTES: Strip Pit Mining Area

20 ft / 2.24 mi = 8.93

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
RAPID BIOASSESSMENT DATA FIELD SHEET

Waterbody Name North Branch Otter Creek Location Private Bridge NE 1/4 Sec 23 Reach/Mile Point
Latitude/Longitude County Vigo
Station Number State IN Aq. Ecoregion
Time Agency IDEM Investigators Date 3 Oct
Notes Hydrologic Unit Code Form Completed By

Physical Characteristics/Water Quality Field Sheets

RIPARIAN ZONE/INSTREAM FEATURE:
Predominant Surrounding Land Use:
FOREST FIELD/PASTURE AGRICULTURAL RESIDENTIAL COMMERCIAL INDUSTRIAL OTHER
Local Watershed Erosion: NONE MODERATE HEAVY
Local Watershed NPS Pollution: NO EVIDENCE SOME POTENTIAL SOURCES OBVIOUS SOURCES
Estimated Stream Width: 14.8 m Estimated Stream Depth: Riffle .05 m Run .2 m Pool 7
Estimated Distance Between Riffles 10 m Estimated Distance Between Bends 50 m
High Water Mark 1 m Velocity Mod Dam Present: YES NO Channelization YES N
Canopy Cover: OPEN PARTLY OPEN PARTLY SHADED SHADED

SEDIMENT/SUBSTRATE:
Sediment Odors: NORMAL SEWAGE PETROLEUM CHEMICAL ANAEROBIC NONE OTHER
Sediment Oils: ABSENT SLIGHT MODERATE PROFUSE
Sediment Deposits: SLUDGE SAWDUST PAPER FIBER SAND RELICT SHELLS OTHER
Are the undersides of stones which are not deeply embedded black: YES NO

INORGANIC SUBSTRATE COMPONENTS

Substrate Type	Diameter	Percent Comp. in Area Samp.
Bedrock	—	20% 40% 60% 80% 100%
Boulder	10.0 in	20% 40% 60% 80% 100%
Cobble	2.5-10 in	20% 40% 60% 80% 100%
Gravel	0.1-2.5 in	20% 40% 60% 80% 100%
Sand	gritty	20% 40% 60% 80% 100%
Silt		20% 40% 60% 80% 100%
Clay	slick	20% 40% 60% 80% 100%

ORGANIC SUBSTRATE COMPONENTS

Substrate Type	Characteristics	Percent Comp. in Area
Detritus	Sticks, Wood Course Plant Material CPOM	20% 40% 60% 80% 100
Muck/Mud	Black, Very Fine Organic FPOM	20% 40% 60% 80% 100
Marl	Grey with Shell Fragments	20% 40% 60% 80% 100

WATER QUALITY
Temperature 10.4 Dissolved Oxygen 7.0 pH 7.4 Conductivity 897 Other
Instruments Used
Stream Type: COLDWATER WARMWATER
Water Odors: NORMAL SEWAGE PETROLEUM CHEMICAL NONE OTHER
Turbidity: CLEAR SLIGHTLY TURBID TURBID OPAQUE
OTHER

WEATHER CONDITIONS:

PHOTOGRAPH NUMBERS:

OBSERVATION AND/OR SKETCH:

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
HABITAT ASSESSMENT FIELD DATA SHEET

HABITAT PARAMETERS	EXCELLENT	GOOD	FAIR	POOR
BOTTOM SUBSTRATE/ AVAILABLE COVER (ie rubble, gravel, logs, undercut banks etc)	GT 50% Stable habitat	50% - 30% Adequite habitat	30% - 10% Less than desireable habitat	LT 10% Lack of habitat obvious
SCORE=	20 -16 ____	15 - 11 15	10 - 6 ____	5 - 0 ____

EMBEDDEDNESS

GRAVEL, COBBLE, AND BOULDER PARTICLES HAVE ____ % OF THIER SURFACE COVERED BY FINE PARTICLES.

	0 - 25%	25%-50%	50%-75%	over 75%
SCORE=	20 - 16 ____	15 -11 12	10 - 6 ____	5 - 0 ____

FLOW OR VELOCITY/DEPTH (a or b)

a: IF FLOW LE 5 cfs: COLD:	GT 2 cfs	2-1 cfs	1-0.5 cfs	LT 0.5 cfs
WARM:	GT 5 cfs	5-2 cfs	2-1 cfs	LT 1.0 cfs
a: SCORE=	20 -16 ____	15 -11 ____	10 - 6 ____	5 - 0 ____
b: IF FLOW GT 5 cfs: VELOCITY/DEPTH 1) SLOW/DEEP 2) SLOW/SHALLOW 3) FAST/DEEP 4) FAST/SHALLOW	All present	3 of 4 present	2 of 4 present	Dominated by by one (ie pools)
b: SCORE=	20 - 16 ____	15 - 11 14	10 - 6 ____	5 - 1 ____

(slow=LT 0.3 m/s; deep=GT 0.5 m) (Select lower score if more riffle/run missing than pools

CHANNEL ALTERATION	Little or no enlargement of islands or point bars, and/or no channelization	Some new increase in bar formation, mostly from course gravel and/or some' channelization present	Moderate deposition of new gravel, course sand on old and new bars; pools partially filled w/silt; and/or embankments on both banks.	Heavy deposites of fine material increased bar development; most pools filled w/ silt; and/or extensive channelization.
SCORE=	15 - 12 ____	11 - 8 ____	7 - 4 7	3 - 0 ____
BOTTOM SCOURING AND DEPOSITION	Less than 5% of bottom affected by scouring and deposition	5%-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	30%-50% affected Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	More than 30% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle areas.
SCORE=	15 - 12 ____	11 - 8 11	7 - 4 ____	3 - 0 ____

HABITAT ASSESSMENT FIELD DATA SHEET
(continued)

a: POOL/RIFFLE RATIO OR b: RUN/BEND-RATIO	RATIO= 5 - 7 Variety of habitat Deep riffle and pools.	RATIO= 7 - 15 Adequite depth in pools and riffles Bends provide habitat.	RATIO= 15 - 25 Occasional riffle or bend. Bottom contours provide some habitat.	RATIO= GT 25 A straight stream Flat water or shallow riffle Poor Habitat.
SCORE=	15 - 12 12	11 - 8 ____	7 - 4 ____	3 - 0 ____

(Distance between a: riffles or b: distance between bends, divided by Stream Width)

BANK STABILITY	Stable. No evidence of erosion or bank failure. Side slopes generally LT 30% al Little potential for future problem	Moderate Stable. Infrequent, small areas of erosion mostly healed over Side slopes up to 40% on one bank. High erosion potential in extreme floods	Moderate unstable Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks and bends. ential during extreme high flow.	Unstable. Many eroded areas Side slopes GT 60% common Raw areas frequent along straight sections
SCORE=	10 - 9 ____	8 - 6 8	5 - 3 ____	2 - 1 ____

BANK VEGETATIVE STABILITY	THE STREAMBANK SURFACES COVERED BY GT 80%	79% - 50%	% VEGETATION OR BOULDERS AND COBBLE. 49% - 25%	LT 25%
SCORE=	10 - 9 ____	8 - 6 7	5 - 3 ____	2 - 0 ____

STREAMSIDE COVER	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or forbes.	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings.
SCORE=	10 - 9 9	8 - 6 ____	5 - 3 ____	2 - 0 ____

TOTAL OF COLUMN SCORES	TOTAL 21	TOTAL 67	TOTAL 7	TOTAL ____

HABITAT ASSESSMENT TOTAL SCORE 95

Ohio EPA Site Description Sheet - Fish

QHEI SCORE: 76

Stream North Branch Otter Creek Seg 49 RM ____ Date 18 OCT 91 River Code ____

Location Private Bro NE 1/4 Sec 23 Vigo Co Crew: SAN SPW

1] SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Check all types present);

SUBSTRATE SCORE: 16 / 17

TYPE	POOL	RIFFLE	TYPE	POOL	RIFFLE
☐☐-BLDER /SLABS[10]	✓	✓	☑☐-GRAVEL [7]	✓	✓
☐☐-BOULDER [9]	✓	✓	☐☐-SAND [6]	✓	✓
☐☑-COBBLE [8]	✓	✓	☐☐-BEDROCK[5]		
☐☐-HARDPAN [4]			☐☐-DETRITUS[3]	✓	
☐☐-MUCK [2]			☐☐-ARTIFIC.[0]	✓	

SUBSTRATE QUALITY

Substrate Origin (Check all)
- ☐-LIMESTONE [1]
- ☑-RIP/RAP [0]
- ☑-TILLS [1]
- ☐-HARDPAN [0]
- ☑-SANDSTONE [0]
- ☐-SHALE [-1]
- ☑-COAL FINES [-2]

Silt Cover (Check One)
- ☐-SILT HEAVY [-2]
- ☐-SILT MODERATE [
- ☐ - SILT NORMAL [0]
- ☑-SILT FREE [

Extent Of Embeddness (Check One)
- ☐—EXTENSIVE [-2]
- ☑—MODERATE
- ☐—LOW[0]
- ☐—NONE[1]

TOTAL NUMBER OF SUBSTRATE TYPES: ☑> 4 [2] ☐— <= 4 [0]

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)

COMMENTS ____

2] INSTREAM COVER

COVER SCORE: 15 / 14

TYPE (Check All That Apply)
- ☑-UNDERCUT BANKS [1]
- ☑-OVERHANGING VEGETATION [1]
- ☑-SHALLOWS (IN SLOW WATER) [1]
- ☑-DEEP POOLS [2]
- ☑-ROOTWADS [1]
- ☑-BOULDERS [1]
- ☐ -OXBOWS [1]
- ☐ -AQUATIC MACROPHYTES [1]
- ☑-LOGS OR WOODY DEBRIS [1]

AMOUNT (Check ONLY One or check 2 and AVERAGE)
- ☐ - EXTENSIVE > 75% [11]
- ☑-MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

COMMENTS: ____

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

CHANNEL: 17

SINUOSITY
- ☑-HIGH [4]
- ☐ - MODERATE [3]
- ☐ - LOW [2]
- ☐ - NONE [1]

DEVELOPMENT
- ☐ - EXCELLENT [7]
- ☑-GOOD [5]
- ☐ - FAIR [3]
- ☐ - POOR [1]

CHANNELIZATION
- ☐ - NONE [6]
- ☐ - RECOVERED [4]
- ☑-RECOVERING [3]
- ☐ - RECENT OR NO RECOVERY [1]

STABILITY
- ☑-HIGH [3]
- ☐ - MODERATE [2]
- ☐ - LOW [1]

MODIFICATIONS/OTHER
- ☐ - SNAGGING
- ☐ - RELOCATION
- ☑-CANOPY REMOVAL
- ☐ - DREDGING
- ☐ - IMPOUND.
- ☐ - ISLANDS
- ☐ - LEVEED
- ☑-BANK SHAPING
- ☐ - ONE SIDE CHANNEL MODIFICATIONS

COMMENTS: ____

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank)

RIPARIAN: 5

"River Right Looking Downstream"

RIPARIAN WIDTH L R (Per Bank)
- ☐☐-WIDE>50m [4]
- ☑☑-MODERATE 10-50 [3]
- ☐☐-NARROW 5-10m [2]
- ☐☐-VERY NARROW 1-5m [1]
- ☐☐-NONE[0]

EROSION/RUNOFF - FLOOD PLAIN QUALITY L R (Most Predominant Per Bank)
- ☑☑-FOREST, SWAMP [3]
- ☐☐-OPEN PASTURE/ ROWCROP[0]
- ☐☐- RESID.,PARK,NEW FIELD [1]
- ☐☐-FENCED PASTURE [1]

L R (Per Bank)
- ☐☐-URBAN OR INDUSTRIAL[0]
- ☐☐-SHRUB OR OLD FIELD[2]
- ☐☐-CONSERV. TILLAGE [1]
- ☐☐-MINING/CONSTRUCTION [0]

BANK EROSION
- ☐ ☐-NONE OR LITTLE [3]
- ☑ ☑-MODERATE [2]
- ☐ ☐-HEAVY OR SEVERE[1]

COMMENTS: ____

POOL/GLIDE AND RIFFLE/RUN QUALITY

POOL: 9

MAX. DEPTH (Check 1)
- ☑->1m [6]
- ☐- 0.7-1m [4]
- ☐- 0.4-0.7m [2]
- ☐- < 0.4m [1]
- ☐—<0.2m [Pool = 0]

MORPHOLOGY (Check 1)
- ☑-POOL WIDTH > RIFFLE WIDTH [2]
- ☐-POOL WIDTH = RIFFLE WIDTH [1]
- ☐-POOL WIDTH < RIFFLE W. [0]

POOL/RUN/RIFFLE CURRENT VELOCITY (Check All That Apply)
- ☐-TORRENTIAL[-1]
- ☐-FAST[1]
- ☑-MODERATE [1]
- ☐-SLOW [1]
- ☐-EDDIES[1]
- ☐-INTERSTITIAL[-1]
- ☐-INTERMITTENT[-2]

☐-NO POOL[0]

COMMENTS: ____

RIFFLE: 3

RIFFLE/RUN DEPTH
- ☐ - GENERALLY >10 cm,MAX>50 [4]
- ☐ - GENERALLY >10 cm,MAX<50 [3]
- ☑-GENERALLY 5-10 cm [1]
- ☐ - GENERALLY < 5 cm [Riffle = 0]

RIFFLE/RUN SUBSTRATE
- ☑-STABLE (e.g.,Cobble, Boulder) [2]
- ☐-MOD. STABLE (e.g.,Pea Gravel) [1]
- ☐-UNSTABLE (Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐-EXTENSIVE [-1]
- ☑-MODERATE[0]
- ☐-LOW. [1]
- ☐-NONE[2]

☐-NO RIFFLE[0]

COMMENTS ____

GRADIENT: 10

6] Gradient (feet/mile): 8.93 8.9 %POOL: 10 %RIFFLE: 1 %RUN: 89

a 14.8 m

EPA 4520

Waterbody Name North Branch Otter Creek | Location Private Prop NE1/4 Sec 23

Reach/Milepoint | Latitude/Longitude

County Vigo | State | Aquatic Ecoregion

Station Number | Investigators [illegible]

Date 18 Oct 91 | Time | Agency

Hydrologic Unit Code | Form Completed By [illegible]

Reason for Survey

Rapid Bioassessment Protocol III

Biosurvey Field Data Sheet

RELATIVE ABUNDANCE OF AQUATIC BIOTA

Periphyton	0	1	2	3	4
Filamentous Algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Slimes	0	1	2	3	4
Macroinvertebrates	0	1	2	3	4
Fish	0	1	2	3	4

0 = Absent/Not Observed 1 = Rare 2 = Common 3 = Abundant 4 = Dominant

MACROBENTHOS QUALITATIVE SAMPLE LIST (Indicate Relative Abundance: R = Rare, C = Common, A = Abundant, D = Dominant)

Porifera		Anisoptera		Chironomidae	
Hydrozoa		Zygoptera		Plecoptera	
Platyhelminthes		Hemiptera		Ephemeroptera	R
Turbellaria		Coleoptera	C	Trichoptera	A
Hirudinea		Lepidoptera		Other	
Oligochaeta		Sialidae			
Isopoda		Corydalidae	A		
Amphipoda		Tipulidae			
Decapoda		Empididae			
Gastropoda	C	Simuliidae			
Bivalvia		Tabanidae			
		Culicidae			

Rare < 3 Common 3 — 9 Abundant > 10 Dominant > 50 Estimated

CPOM SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group)

Shredders | Total Org. in Sample

Observations

Fantail Darter